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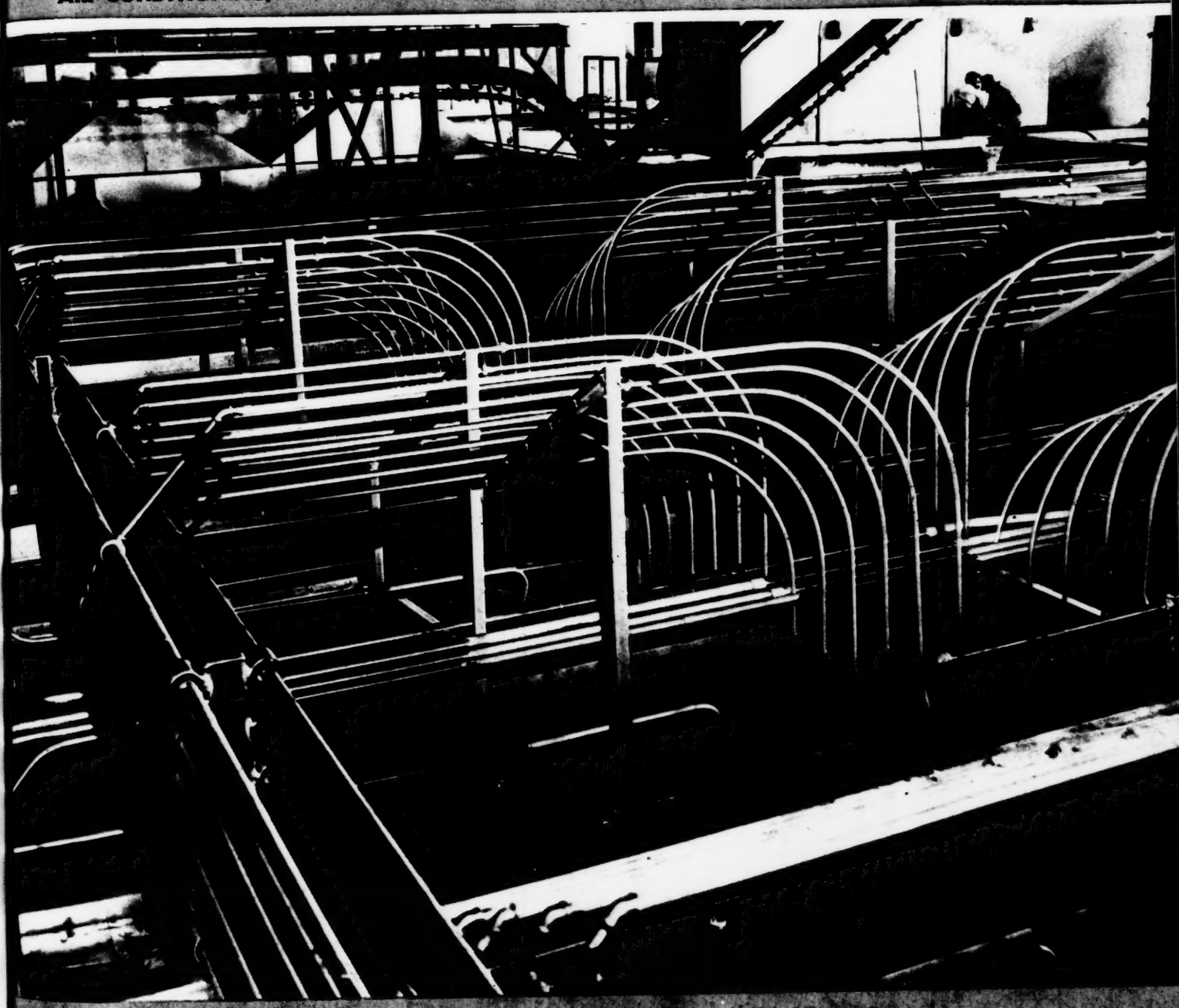
AIR CONDITIONING, REFRIGERATION, PIPING, AIR SANITATION, HEATING AND VENTILATION



Network of pipe lines used to convey paints to spray booths of Kaiser-Frazer automobile body conveyor line. For details of joining pipe by screwed joints see article by J. E. York beginning on page 76

Heat from Earth for the Heat Pump . . page 69

Welding by Inert-Arc Process . . . page 83

Open vs. Closed Panel Heating . . . page 99

Know Your Patent Law . . . page 105

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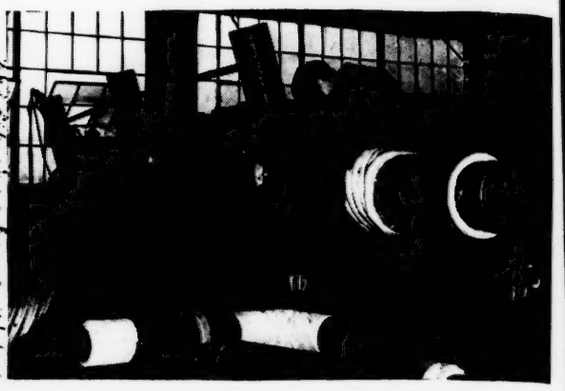

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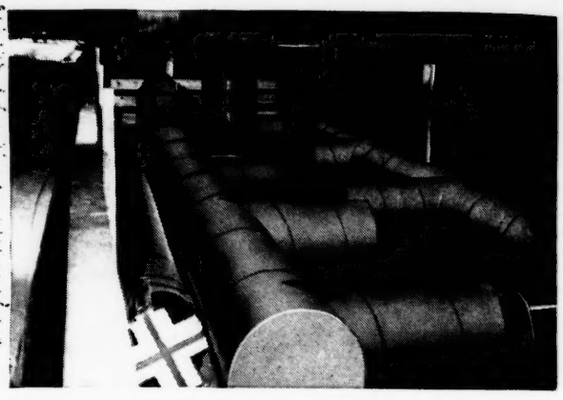

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A MONTHLY MAGAZINE FOR ENGINEERS AND CONTRACTORS CONCERNED WITH THE DESIGN AND APPLICATION OF AIR CONDITIONING, REFRIGERATION, PIPING, AIR SANITATION, HEATING AND VENTILATION IN BUILDINGS

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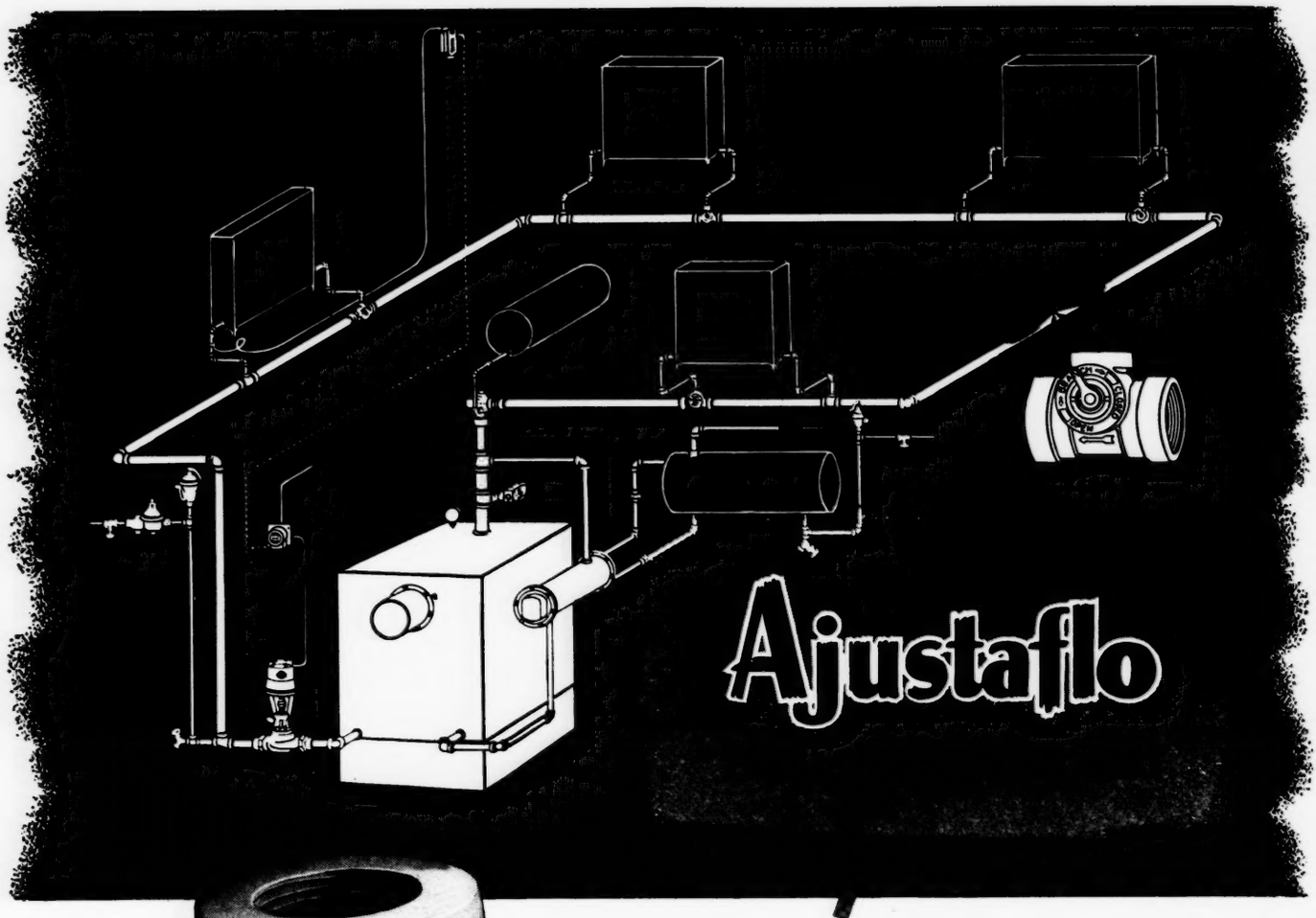
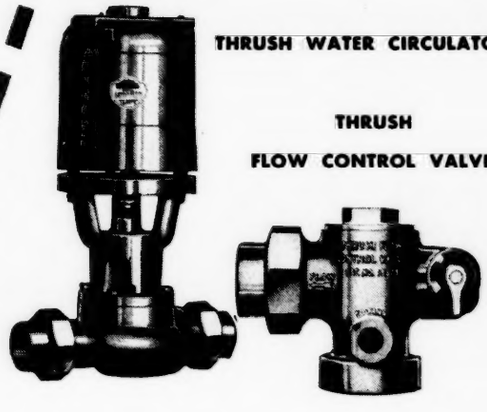
THIS MONTH

At the present time there is considerable interest in securing all available information regarding the heat pump—how it functions, its economics, how it obtains its heat. In an article on page 69, Dr. E. N. Kemler describes various methods for obtaining heat from the earth for heat pump operation.





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Washington News

LORING F. OVERMAN

ANY suspicion that the Washington influence, with Congress adjourned, might fade from the business horizon for at least a brief moment, was quickly dispelled during the steamy days of August. Indeed, there are those who attribute at least part of the almost nationwide hot spell to going's-on in the Capitol City. Among the temperature-raisers were the following:

Some 150 Congressmen and Senators comprising more than a score of investigating committees started spinning the query wheels . . . and where they'll stop, nobody knows!

The Justice Department got the "Go" sign on monopoly inquiries; started with steel, tires and film, moved to oil, and has other industries in mind.

On August 23 the Taft-Hartley Labor law became fully operative; management's elation over its passage somewhat dimmed by early union successes in circumventing some of the provisions.

And superimposed over all of these Washington activities was its concern over the hazy foreign picture, with emphasis on the probable effect of the British sterling-dollar famine on export markets.

Investigation Fireworks

The Congressional investigation program, despite starting with the Hughes aircraft roar and dwindling to somewhat of a fizzle, has a docket of world-wide scope. In a program so diversified, it seems inevitable that something will be turned up that will be of direct interest to the Heating, Ventilating and Air Conditioning Industries.

First place to look, of course, will be at the series of hearings planned to plumb the depths of the housing shortage. Leaving that subject for the moment, it is interesting to note that between now and the reconvening of Congress next January, Congressional committees will conduct inquiries into the condition of European nations and British dominions in relation to possible aid under the Marshall plan; the situations in Korea and China; immigration legislation and displaced persons, the State Department's information program, administrative "propagandizing" of Congress; labor management relations and union practices; cost of living, tax revision, agriculture, and relations between Federal, State and Local governments.

Nor are these all. Also slated for inquiries are surplus property disposal, world health, sugar and shipping, foreign trade in general, public works, air policy, politics in postmaster appointments, the Philadelphia Newspaper Guild, elections in Maryland and West Virginia, Alaskan lands and airports, critical materials shortages, particularly in the steel industry; the plight of independent miners, practices of James Petrillo, president of the American Federation of Musicians, and reports of Communist influence in Hollywood and elsewhere.

Of the foregoing, it is probable that hearings of greatest interest to readers of this column will concern steel facilities, and possibly the proposed tax revision program. On this latter subject, the House Ways and Means Committee will reopen hearings in November in the hope of having a general tax revision bill ready when Congress meets in January. A general Advisory Committee, headed by former Undersecretary of the Treasury Roswell Magill, is assisting the committee.

Housing Probe Important

When Congress established a joint Senate-House committee on housing and directed it to bring in certain answers by March 15, it was not anticipated that the committee itself would cross bats even before the inquiries were started. The bat-crossing came when Senator McCarthy opposed Senator Tobey's efforts to be named chairman of the committee. Representative Ralph A. Gamble, New York Republican, wound up as the compromise chairman, but it appears there was more to it all than merely a matter of personalities. During the election procedures, Senator Tobey charged that "a sinister group" was trying to destroy the inquiry. The Senator declined to identify the group, but Washington observers comment that the switch in chairmanship was in reality a move to further stymie the Taft long range housing bill. This measure has died with the adjournment of two sessions of Congress, but is on the Senate calendar for debate when Congress reconvenes.

Senator Tobey has favored the bill, with Senator McCarthy opposing.

Thus there is the likelihood that, with the committee so divided, its investigation of the construction picture will result in two reports—one slanted to present the Taft proposal as the solution; the other favoring other remedies.

It is to be hoped that this pre-judging of the committee's conclusions will prove incorrect, for Congress has recognized the need for a down-to-earth investigation, and has authorized expenditure of $100,000 of taxpayers' money in an effort to find the solution to a paradox. The puzzle lies in the fact that as a nation we have demonstrated our ability to employ mechanical skill and ingenuity in the production of so many complicated devices, within price ranges that make them available to the masses, while failing to bring suitable housing within the means of the average citizen.

The joint committee on housing has been asked by Congress to get answers to such questions as these: extent of the need for housing; extent to which shortage of materials contributes to the housing shortage; reasons for the high cost of building, in materials and other factors making up this cost; the extent to which archaic building codes hamper building; availability

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of private capital and Government money to finance building, and among others, the extent and effect of alleged restrictive practices in labor and industry upon costs.

If the committee can bring in answers uncolored by bias, political or otherwise, and can suggest procedures that may break existing bottlenecks, the hundred grand at its disposal will have been well spent.

Construction Unit Active

While Congress seeks answers to overall problems, the Construction Division of the Department of Commerce, through publication of its monthly reports of Construction and Construction Materials, continues to offer evidence that industry is busy and that eventual solution to the shortage is in the offing. A current release, for example, lists 16 new developments in the building products field. The Construction Unit explains, however, that it is merely relaying manufacturers' descriptions; that it assumes no responsibility for claims. Too, there is always the question of whether the suggested development will run afoul of building codes. Copies of the list, containing several items in the heating and air-conditioning field, may be secured by writing Construction Division, Department of Commerce, Washington 25, D. C., requesting the July Industry Report on Construction and Construction Materials.

Also available at the same address are two publications designed to aid building officials and others interested in the modernization and revision of building codes. Their titles are CD-1 "Publications Related to the Preparation and Revision of Building Laws", and CD-2 "Work Sheet for Checking the Dates of Standards and Specifications Incorporated by Reference in Building Laws."

Price Witch-Hunt

Looking again at the monopoly investigations previously mentioned as temperature-raisers, more than one Washington observer considers these an effort to frighten business into holding the price line—a substitute for President Truman's previous request that the line be held voluntarily. Comments the Chamber of Commerce of the United States: "Whatever happens to prices, there is plenty of evidence that the high cost of living is becoming a national issue. One sign of this growing concern with prices is the announced Justice Department hunt for price-fixing plots. The implication of the investigation is that some individuals, or groups, are responsible for the rise in prices. But it is well to keep the record straight on the sources of inflation if there is to be any official hunt for scapegoats to take the rap for the high cost of living. They won't have to go far. The trail starts right in Washington. As in the World War I rise in prices, the basic source of the World War II inflation is government fiscal policy."

The Chamber contends that one of the basic causes of high prices is the shortages caused in part by an increase of 9,160,000 in population since 1940. It urges that government fiscal policy be changed to encourage capital investment in facilities to provide goods needed to fill war-postponed requirements, as well as those of the newcomers.

Again the interlocking of Washington activities is demonstrated. On the one hand prosecutions seek to force prices down; on the other a House Ways and Means Committee plans hearings that will determine taxing policies having a direct bearing on future production. Representatives of the heating, ventilating and air-conditioning industries may wish to make themselves heard while these conflicting policies are under discussion.

Labor Day, 1947

Currently, the labor law changes so desired by management offer a challenge in public relations, human relations, employee relations. Provisions which may tempt employers to crack down should be used sparingly. Instead the equitable phases of the law should be explained and demonstrated to every employee. To date he has heard but one side of the story —the labor leaders' side. American workmen are inherently fair-minded. It is unnatural for them to bite the hand that feeds them. The average employee would prefer to work *with*, rather than *for* his boss, if he is convinced that his boss is on the square.

Industry has a job to do—that of winning the support of labor, instead of trying to force that support. Recalling the last 15 years of union-favoring legislation, the temptation to turn the tables may be strong. Such a policy should be discarded in favor of one that says: "Boys, for many years I haven't been permitted to tell you just how closely your future is linked with mine. But here are the facts, and here is how we can all work together for mutual good." And so on down the line, selling the advantages of cooperation; warning of the dangers of efforts by either management or labor, to try to get something for nothing.

Labor leaders are sitting up nights figuring out ways to circumvent the new labor law; charting political campaigns seeking revenge at the polls in 1948. Repeal of the Taft-Hartley law in '48 is their goal. At stake for some of the leaders are merely lush salaries. At stake for management, and for the rank and file worker, is a more productive, a more prosperous America. Both management and the labor leaders have the same material to work with—men's minds, their understanding, their sense of fairness, their self-interest.

The World Situation

Despite the threat to export trade implied by crises throughout the world, particularly in Britain, conditions abroad offer the best possible argument for a renewal of that confidence whereby management and labor built this country to its present position of prosperity. Name any other country, any other economic system, and the picture is one of chaos, privation and misery. What American workman would trade places with a workman anywhere else in the world!

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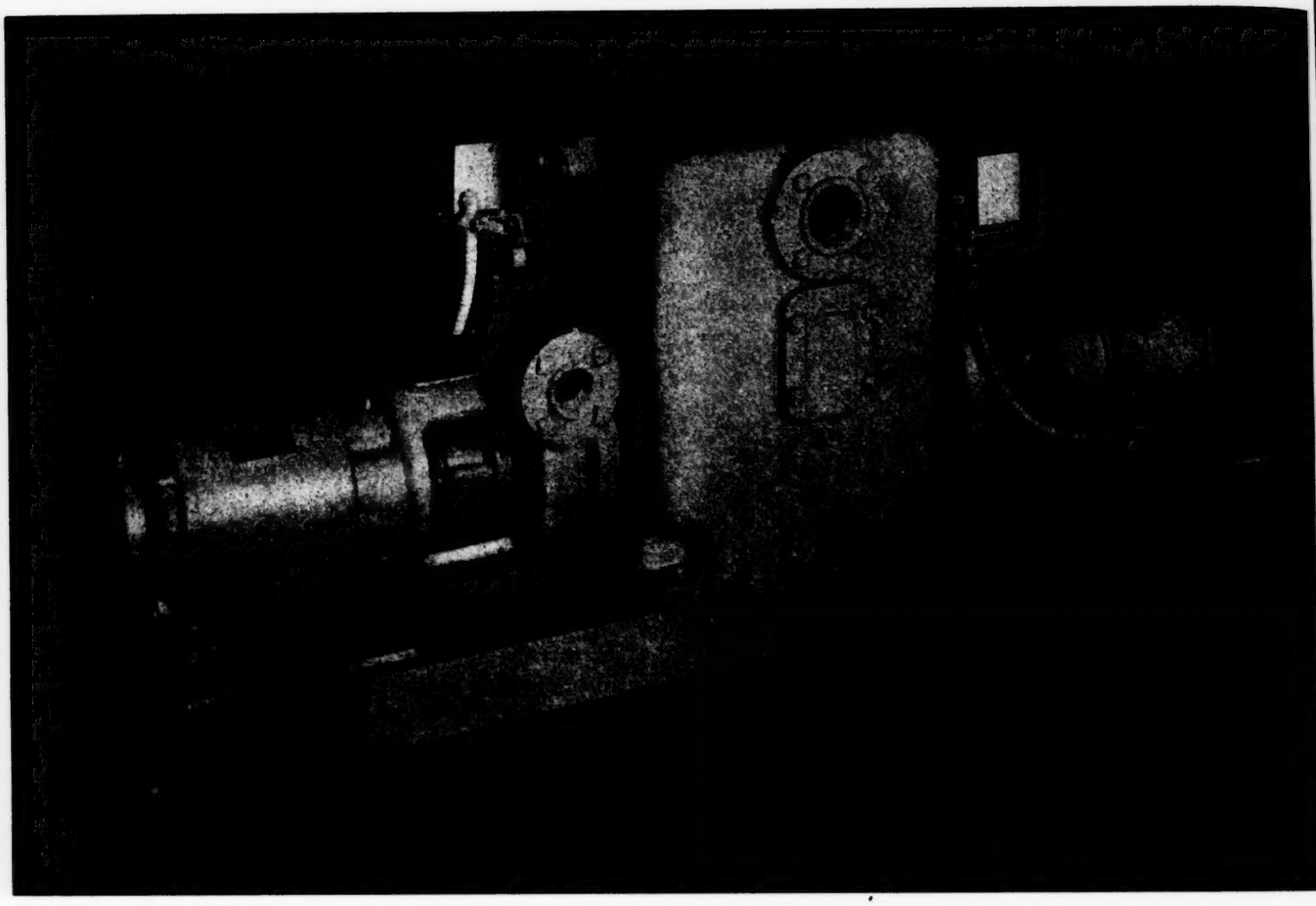

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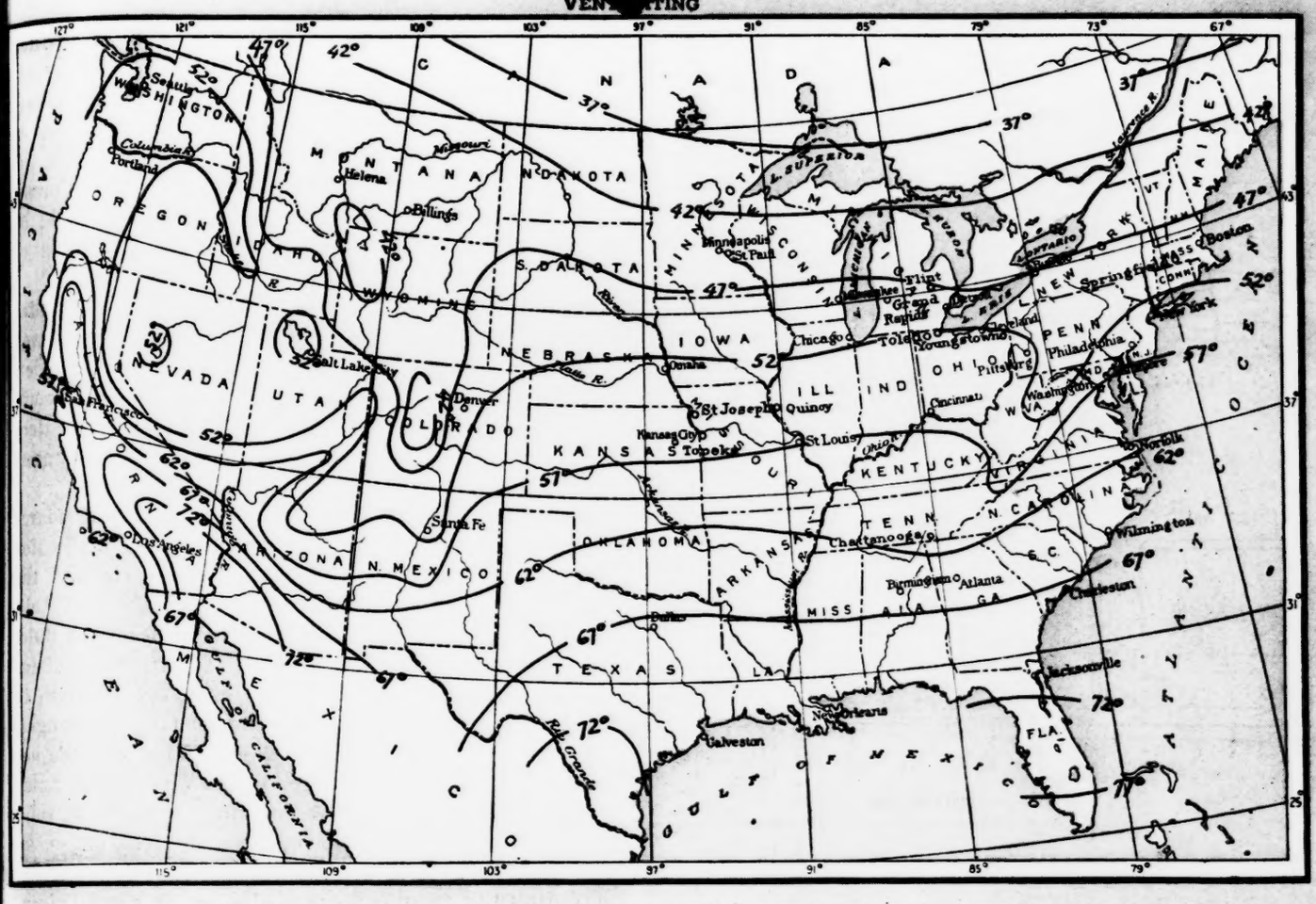

Fig. 1. U. S. Geological Survey map showing approximate temperature of water from non-thermal wells at depths of 30 to 60 ft.

Methods of Earth Heat Recovery for the Heat Pump

E. N. KEMLER

Assistant Director of Research and Research Professor of Mechanical Engineering, College of Engineering, New York University, New York

THERE has been much discussion of using the earth as a heat source in connection with the heat pump and year-round home conditioning. The earth as a heat source is the one way of making heat pump operation practical throughout the United States. For example, earth temperatures at a depth of 30 ft along a contour running through New York, Cleveland and Chicago areas, see Fig. 1, average 52F. This temperature is essentially constant throughout the year below this depth and further increases about 1F for each 60 ft increase in depth. Fig. 1, a map prepared by the U. S. Geological Survey, shows the average earth or ground water temperatures at a depth of about 30 ft and shows that ground temperatures are sufficiently high throughout the country to get reasonable heat pump performance independent of climatic conditions. In the South, the heat source is available at temperatures which should be very attractive insofar as earth heat source is concerned. The problem of heat for the heat pump is, therefore, not where to get the heat from but rather how it can be obtained economically from the earth. This article will discuss some of the methods which have been used or proposed in connection with obtaining heat from the earth.

Most of the early heat pump applications used well water as a source of heat. Such a system would be as indicated in Fig. 2. For isolated locations, this can be done without damage to ground water resources. However, if practised by a large number of residences, the effect on the ground water supply would be serious, both with respect to its depletion and the problem of obtaining a sufficient quantity for proper heat pump operations.

From an operating standpoint, the utilization of well water, as indicated in Fig. 2, would not be entirely desirable because of the scale deposits which

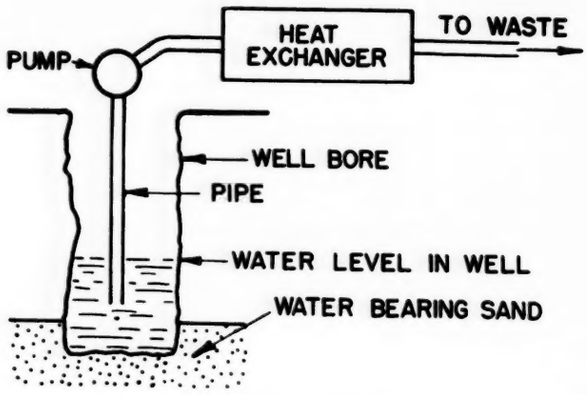

Fig. 2. Simple well.

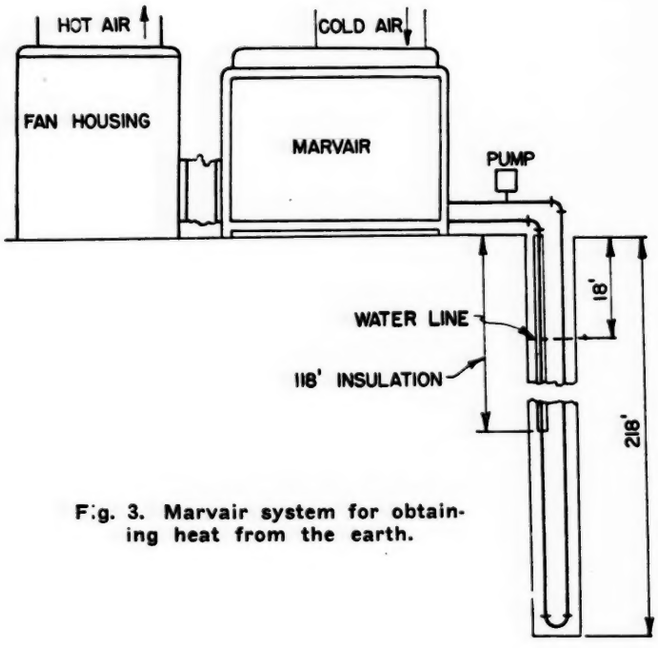

Fig. 3. Marvair system for obtaining heat from the earth.

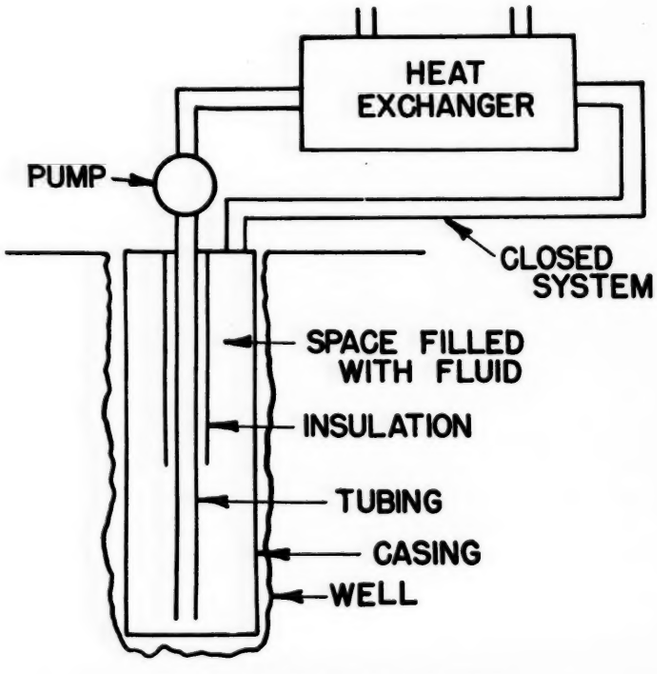

Fig. 4. Modified U-tube system.

would result in the heat exchangers. The deposition of small amounts of scale would reduce the heat exchanger effectiveness, which in turn would decrease the efficiency of heat pump operation. The use of ground water directly, that is, pumping it from the ground and washing it is not practical for urban areas. Even if available the load on the sewers, would be greatly increased, and it would affect operation of sewage disposal plants.

As an alternative, the use of dual wells where water is pumped from one well and returned to a second well overcomes some of these objections to use of underground water. The problem, insofar as the rural home is concerned, may be considerably different. Here some use may be made of the water and its disposal is not normally a serious problem.

As a first step in the simplification of heat source and in overcoming these difficulties, with utilization of ground water, Muncie Gear Works proposed the method shown in Fig. 3. This method utilizes a U-tube either in an open well or in a casing filled with fluid. It uses a fluid in a closed system. The fluid circulates continuously and acts as a heat carrying medium to carry heat from the earth to the heating exchanger. No fluid is pumped from the earth. This has the advantage that the temperatures of the circulating fluids do not need to remain above freezing; anti-freeze solution can be used in the circulating system. Also, an inhibitor can be used in the circulating fluid to eliminate difficulty from corrosion. Inasmuch as the circulating fluid used circulates continuously and is not replaced, the deposition of scale is likewise eliminated. In such a system the down pipe is insulated as indicated to keep the warmer fluids that are circulating up from transferring part of this heat to the cooler fluids going down during the heating season, and the reverse during the cooling season. This closed system also has the important advantage in that the only work which the pump has to do is to overcome friction in the system. There is no work in lifting the fluid but only in overcoming friction during its circulation through the system.

When underground water is used directly, the power necessary to pump the water may affect the overall coefficient of performance of the unit. When used in connection with a closed casing, this system is independent of ground water level or sources, inasmuch as all the system does is to transfer heat from the earth

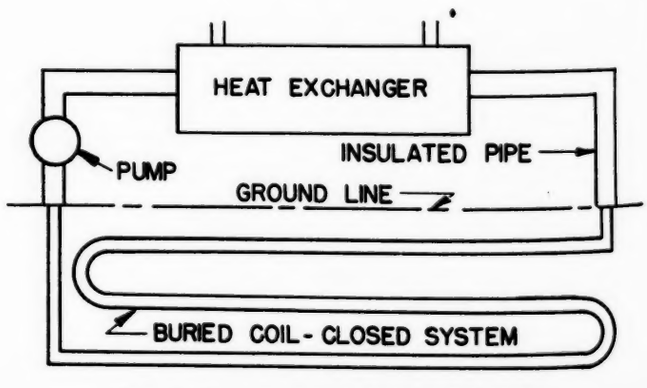

Fig. 5. System employing buried coils.

to the fluid in the casing and in turn to the fluid in the U-tube.

Fig. 4 shows a modified U-tube system, utilizing the casing as the second leg of the U-tube. This has the advantage of requiring one less heat transfer step and a larger surface is attained for the returning fluid to pick up heat from the earth during the heating season or to give heat back to the earth during the cooling season. In the system shown in Fig. 3 the heat must travel through the fluid in the casing before reaching the U-tube. In Fig. 4 the heat is transferred directly from the earth through the casing to the fluid which carries the heat directly to the heat exchanger.

As a modification of this system it has been proposed also that buried pipes, Fig. 5, be used in the backyard to pick up heat. Such pipes would be laid at a depth of 6 to 8 ft below the surface. It is basically the same system shown in Fig. 3 and 4, except that instead of the vertical system, the horizontal heat pick-up system is used. With the utilization of some type of special ditching equipment, small pipe—either copper tubing or steel pipe—could be laid economically to capture the heat from this source.

Utilization of the horizontal coils at depths of less than 6 ft would be seriously influenced by variation in earth temperatures as indicated in Fig. 6. While there is a variation of temperature at depths of 6 ft or below, they are not too serious since the minimum is not reached until late in Spring when the heating requirements have been greatly reduced. In order to be at all effective, the pipes would necessarily need to be buried at a depth of at least 6 ft below the surface and preferably deeper. Because of the smaller diameter considerable pipe would be needed for such a system.

Fig. 7 shows an alternate to this system. It utilizes coils buried in the earth in which the refrigerant itself is circulated. This system has the advantage over the one shown in Fig. 5 in reducing one heat transfer step. It does, however, have the disadvantage requiring very careful engineering in order to insure against leakage of the refrigerant which loss would be serious because of the large volume required and because of the difficulty in finding the leak. It also introduces operating problems such as trapping of oil in the coil.

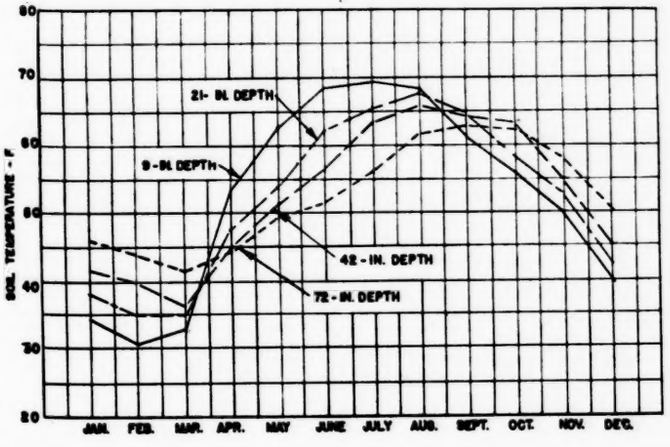

Fig. 6. Seasonal variations in soil temperatures at various depths measured in Pittsburgh in 1941 in well-drained, red clay soil.

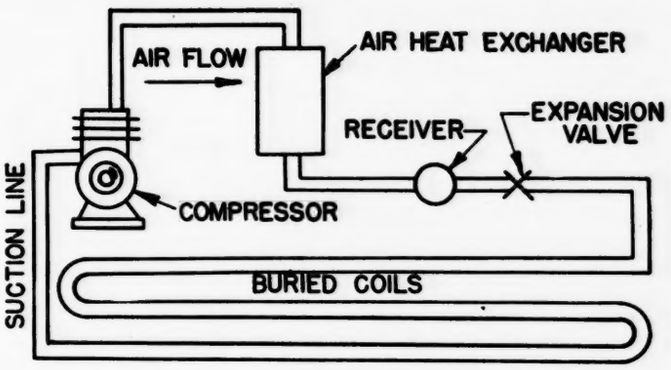

Fig. 7. Refrigerant circulating through buried coils.

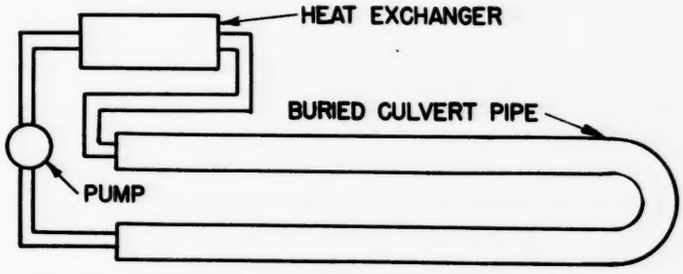

Fig. 8. Buried system with storage.

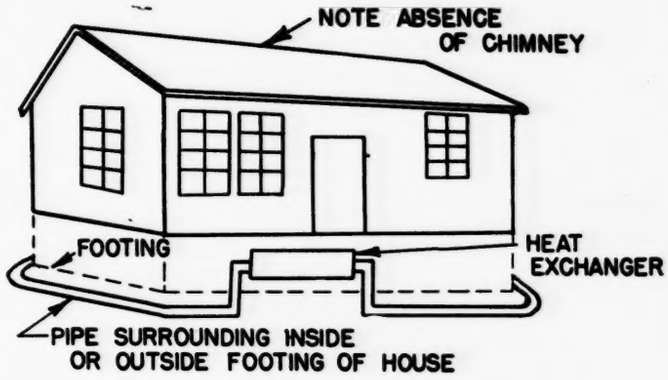

Fig. 9. Buried storage system.

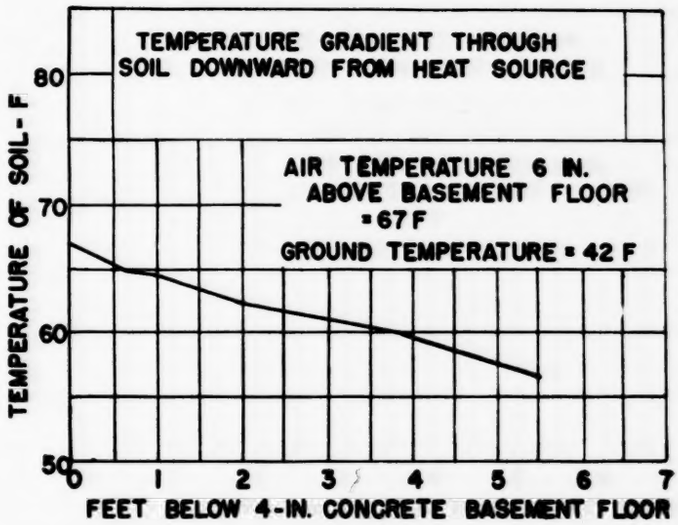
TEMPERATURE GRADIENT THROUGH SOIL DOWNWARD FROM HEAT SOURCE
AIR TEMPERATURE 6 IN. ABOVE BASEMENT FLOOR = 67 F
GROUND TEMPERATURE = 42 F
TEMPERATURE OF SOIL - F
80
70
60
50
0 1 2 3 4 5 6 7
FEET BELOW 4-IN. CONCRETE BASEMENT FLOOR

Fig. 10A. Ground temperatures below heated house.

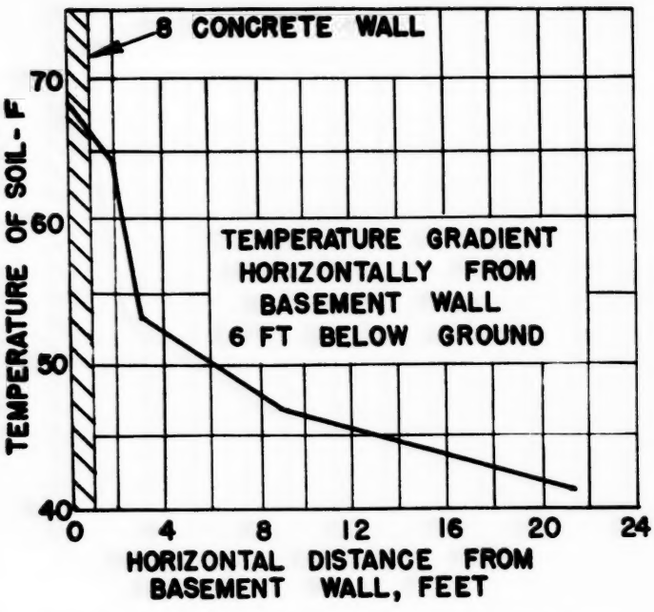

Fig. 10B. Ground temperatures around heated house.

Requirements for depths of coil, amount of pipe, etc. for systems of this type would be essentially the same as those of Fig. 5. Such a system, Fig. 7, would not be limited by temperatures; that is, where low coil temperatures were necessary, anti-freeze would not need to be used, inasmuch as the refrigerant itself is used in the coils. Since such low temperatures would mean low coefficient of performance, it is doubtful if this would be a factor in a competitive unit.

A further modification of the indirect earth system as shown in Fig. 5 has been proposed and is indicated schematically in Figs. 8 and 9. In Fig. 8 it is proposed to utilize something similar to culvert type pipe which has high strength and large surface area at an economical cost and which has, in addition to the large surface area, a high heat storage capacity. Such a system, when filled with fluid, will be able to carry over on peak periods and thereby eliminate one of the difficulties which arise with the utilization of small pipe with low storage capacity. In such a system as shown in Fig. 8 the amount of surface which is required to carry the peak should be substantially lower than that of the other systems.

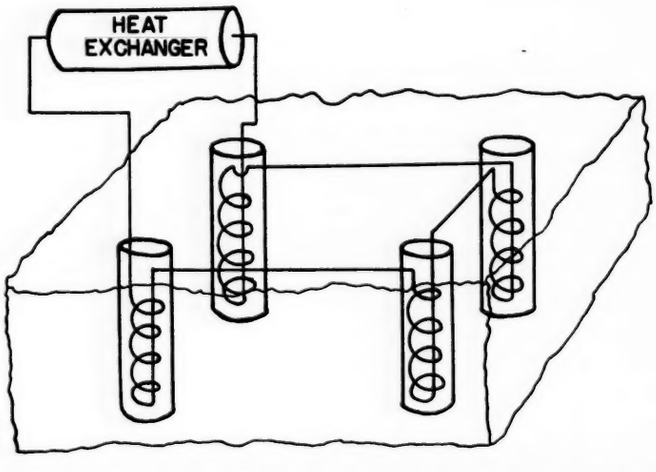

Fig. 11. Buried coils after the design of Union Electric Co.

Fig. 9 indicates a system which can be used in connection with new house construction. By placing the pipe alongside or just above the footing of the basement in a new house, whether inside or out, a very compact system can be obtained that will not interfere with other home activities. In such a case the cost may not be appreciably increased above that for the pipe itself. Such a system as shown in Fig. 9 would have the advantage of weather protection by the house and also would be able to pick up some heat losses from the basement and cellar to the earth. As indicated in Fig. 10 there is some appreciable heat loss from the basement as pictured by temperature curves of normal conditions. While this is not appreciable, it may in some cases be sufficient to reduce the amount of surface required.

Fig. 11 shows a system which has been utilized in connection with attempts to reduce the cost of the heat source. This system contemplates utilizing pole setting boring equipment for boring shallow holes of the order of 15 to 20 ft in the earth and inserting coil pipes within such holes. This gives a means of getting large surface in rapidly at low cost. This system has been utilized with success by the Union Electric Company in an experimental installation in St. Louis.

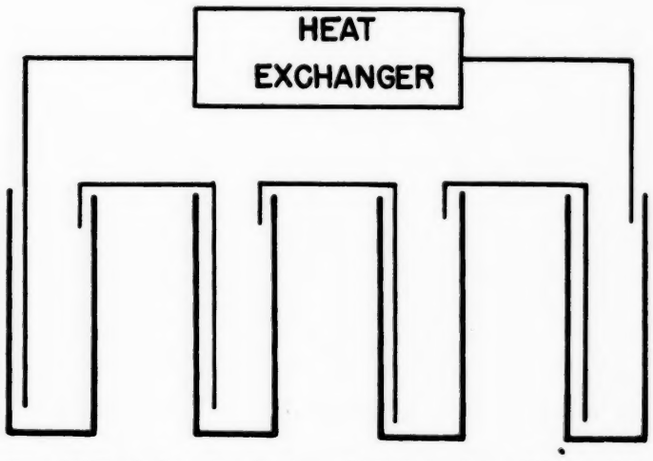

Fig. 12. Buried coils, design of Muncie Gear Works, Inc.

An alternate system corresponding to Fig. 8 is presented in Fig. 12. Short sections of culvert pipes are inserted in bored holes. Here again, the question is whether it is cheaper to bore a number of small holes to a depth of 15 to 20 ft or to drill a deep well. Probably, each of these methods will find some application in particular localities depending on the relative costs and geological conditions.

A number of other methods of tapping the earth for heat have been proposed by Walter Friend, Mechanical Engineer, Ebasco Services, who has pointed out the possibilities of using well point driving methods for tapping earth heat sources which might use a system similar to that indicated in Fig. 4 but with smaller pipe sizes, and to use hydraulic jacking equipment in connection with forcing pipes out through basement walks, etc. All of these methods have possibilities.

Heating Problems in Old Churches

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"DON'T spoil the architecture!"

If ever there was a universal law created to govern the introduction of heating to all churches, and particularly old ones, this is it. There are times when the problems of these old structures bring us uncomfortably close to the impossible.

Consider for example, the case of any Colonial period church that for 100 years or more was heated with a stove or two, or not at all. Now in these days of softer living it has become both a pride to its community and a discomfort to its parishioners. Colonial architects rarely provided us a chimney, and in the low south where water is close to the surface, never a cellar to hold the boiler of today. If we cannot place the boiler in a cellar, we must find another place, perhaps in a separate building, with a church yard in between to complicate the running of underground piping.

To increase our complexities, there is a steadily growing desire to provide summer cooling, to let the church compete, as more than one minister has remarked, with the physical comfort of the movies. Cooling, of course, implies the need for the introduction of chilled air. We can do this if we do not disfigure the architecture by the use of ducts or readily observable grilles, and providing we do not cause either drafts or objectionable sounds from fans. The same limitations also apply to the introduction of warmed air for heating.

Obviously, to meet these restrictions, we must approach every church as being altogether different from every other church, and we must be prepared to modify any and every standard method of heating. Supposing we examine several actual case problems and observe how the development of hybrid systems can become necessary.

For Case No. 1, we select St. Philip's Episcopal Church in Charleston, S. C. This present structure was built in 1835, replacing a church of similar architecture that burned down in the same year. The architecture of St. Philip's follows that of the Jesuits' Church in Antwerp. It has side balconies, windows perhaps 25 ft high, and a tile floor beneath which are located a number of burial vaults. The floor itself is approximately 2 ft above the ground, with several openings to the air that are intended to reduce dampness and discourage termites.

In addition to the church, there is a chapel, 50 ft away, a parish house 150 ft distant, and a church home 100 ft away. The churchyard is filled either to capacity or very close there to. The problem is to heat these buildings from a central plant, and equally desired, in summer cooling for the church.

Fig. 1. Chancel of St. Philip's Episcopal Church, Charleston, S. C.

For architectural reasons the erection of ducts in the church, for either warm or cool air, cannot be accepted. Underfloor ducts are blocked by the vaults. As an added dis-attraction, there is no available room for the installation of heating and cooling coils, fans, and filters to distribute heated or cooled air.

At this point we discover that the chapel, with extraordinary good luck, was built with its floor 6 ft above the ground. We can locate both the boiler and the refrigerating machinery under the chapel. On the north side of the chapel we can erect a stone chimney to match the mellowed walls, and in no manner detract from the architectural gem which is the capel's big sister.

What to do with the steam and refrigerant is still our problem, and we come to the conclusion that cabinet floor units, finished in walnut and mahogany to match the colonial trim of the white walls, is our best plan. These cabinets will replace cabinets of similar appearance that now house gas-fired radiators. It seems likely we can snake the service piping, both steam and refrigerant, between the vaults and under the floor, to the units involved. The underground piping connecting the church units with the machinery

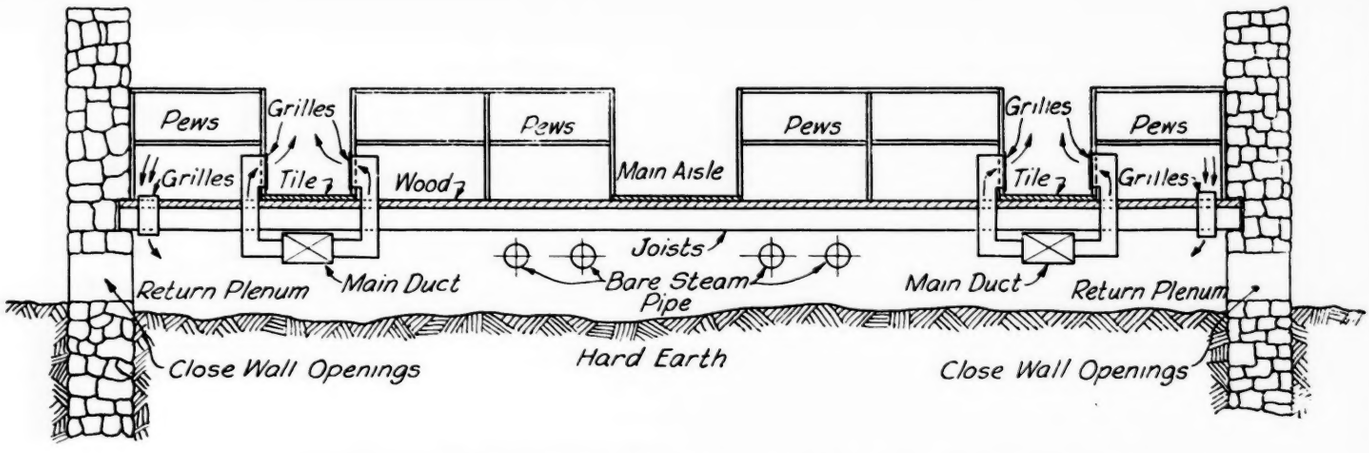

Fig. 2. Proposed church heating system for Case 2. Main aisle return grille not shown.

under the chapel, must follow the narrow footpaths between the tombstones of the churchyard.

Unfortunately, the cost of this system appears quite high, for about 24 cabinets will be required, and, of course, the construction of underground piping is never of minor expense, especially if water is likely to be a problem. However, in a choice between saving money and leaving beauty undisturbed, beauty in Charleston always wins, and this writer subscribes wholeheartedly to that attitude.

Flat stones, just before the chancel steps of this church, Fig. 1, cover vaults, and similar structures not shown, and are encountered as we diverge toward the side aisles.

For Case No. 2, we will examine a proposed method for both heating and cooling another Charleston church, a structure little less venerable than St. Philip's. First inspection of the premises shows us a floor less than 2 ft above the hard earth, tile laid in the aisles, columns but no balcony, and tall, stained glass windows in the side walls. However, we also observe some advantages, such as absence of vaults, no churchyard, and a small courtyard in the rear can be used as a boiler site. Moreover, the floor of the organ room is so raised that we can install both heating and cooling coils, fans and filters beneath it.

Against these assets we must balance several distinctly individual restrictions such as:

1. Pews extend all the way to the side walls, and the attendance is so heavy that we dare not replace a single seat with radiator or discharge grille.

2. Persons occupying these side pews invariably complain at the chill they feel when sitting so near the cold walls, and some measure of heating in these areas is considered essential.

3. Installation of wall panels between the windows to compensate for the wall chill, is not acceptable because the physical nearness of worshippers to these panels is expected to exchange cold discomfort for heated discomfort.

4. The use of baseboard heating will not be accepted either, due to its even slight encroachment on room in the pews.

Of course, panel heating and baseboard heating in either event contribute no solution to our correlated problem of cooling in the summer. We need air for cooling but how shall we introduce this air into the church?

Fig. 2 shows the method believed to best meet these peculiar conditions. Ducts carried underneath the floor will introduce either warmed or cooled air into the side aisles, the risers piercing the floor under the pew seats, where they will not encroach in the least on seating capacity. As these side aisles are notably narrow, not over 36 inches in the clear, and as the pews are open to the aisles, there exists some danger of the air blast causing an uncomfortable draft on persons opposite the points of discharge. To guard against this danger, the discharge grilles are set to face each other across the narrow aisle, and to cause the emerging air currents to meet and become deflected upward. Of course, this problem solution requires some nice balancing of the air discharges, and this balancing is considered tedious perhaps, but not impractical.

An interesting treatment of this church, as shown by Fig. 2, is the creating of a large, under-floor plenum chamber. In winter, the plenum is heated by bare steam pipes, of the number and locations needed to provide a floor temperature of 65F on the coldest days. This plenum also will provide air suction for the fan. To avoid short-circuiting of the air circulation under the floor, some baffling may become necessary, but it is expected that the large volume of air under the floor will so reduce the velocity of air movements that trouble will be unlikely.

Return grilles set in the floor along the side walls will be long and comparatively narrow. They will not reduce pew room, and at the same time will bring warm air from the side aisles over to the walls. The laws of radiation being what they are, some chill from cold outside walls seems inevitably the lot of persons contiguous to them, but present conditions will be improved for at the moment there is no heat of any kind in these areas.

The use of convector cabinets, as described in Case No. 1, is not practical for this church, as there is no floor space on which to set them. We cannot use unit heaters either, because of their discordant clashing with the architecture, plus the fact that unit equip-

ment for satisfactory results, should be set generally with the bottom edges 12 ft or less above the floor.

All in all, the hybrid system described seems most suited to the peculiar limitations and requirements of this church. Compared with Case No. 1, we are struck by the dissimilarities of treatment; what suits one, cannot be applied at all to the other. The one common denominator, if we can call it that, is the need for individual treatment.

One problem of some importance, and solved adequately by the design described in Case No. 2, is the protection of chaste white surfaces, so common in Colonial churches, from smudging by system-carried dust. As in every gathering place, street dust becomes plentiful in churches, being brought in on the clothes and shoes of the congregation. We all know what happens to the walls adjacent to radiators and convectors, and in the vicinity of registers. The same condition can develop in a church.

In Case No. 2, dust carried out of the church on the exhaust air is left in the filters, and the discharge from the pew grilles is clean.

This church dust can become quite difficult to remove, if the interior architecture is embellished with fluted columns and ornate capitals, or if the ceilings are of fan-tracery Gothic. Carved wall panels also provide abiding spots for disfiguring dirt. Any system that tends to reduce the circulation of dust therefore, can claim a point of advantage.

There is another type of heating problem that sometimes develops in old churches, which by its nature has nothing to do either with architecture or air cooling. We might identify this problem as correcting the infirmities of time. The problem arises because, with the passing of years, a heating system, usually steam, that was wholly satisfactory at the time of its installation, can develop cricks in the back, water on the knees, and similar infirmities that bring nothing but opprobrious remarks from persons the system is designed to heat.

As an example of these infirmities and their treatment, we might examine Case No. 3, a Baptist Church in Winter Haven, Fla. Those who believe that Florida always is warm in winter, are referred to the shivering congregation of this church some pleasant Sunday morning when the outside thermometer stands at 20F. The fact that the next day will be warm, with temperatures 40F or 50F higher is of no comfort for the moment. Steam is wanted in the radiators and not promises from the weatherman.

The system in this church was of the one-pipe steam type, approximately 30 years old. No doubt, it suited the job at first, but with the passing of years, several changes occurred more or less imperceptibly. The church settled, and with the structural settling, the pitch of the radiator runouts became so seriously affected that in many cases radiators were divorced from the steam header by deep water-pockets. Radiators may have been added in several rooms, and certainly the boiler insulation fell off, because bare iron was visible everywhere.

The layout of the system, and part of the rehabilitation accomplished, is shown by Fig. 3. First, all radiator runouts were re-graded. New drip lines

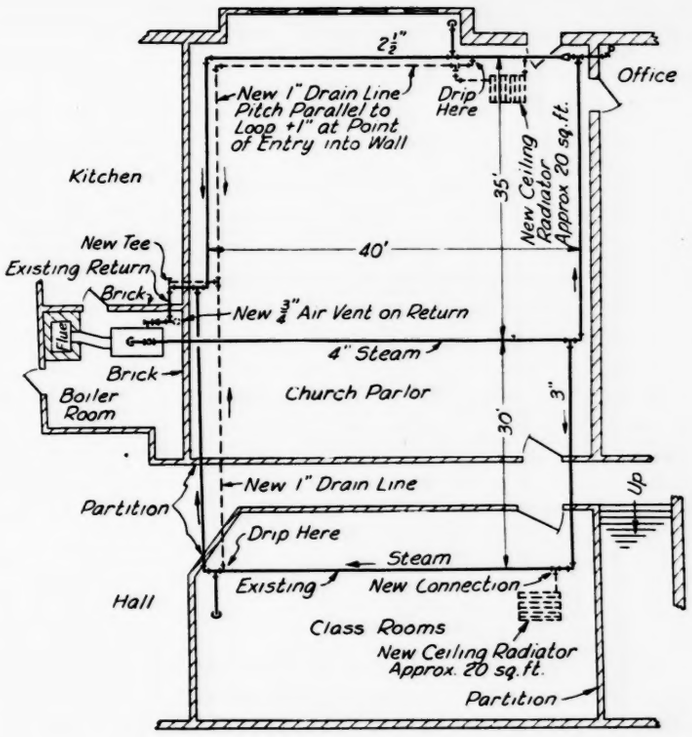

Fig. 3. Dripping one-pipe steam header system—Case 3. Floor dimensions are approximate.

were tied into the steam headers at points indicated, for relieving the headers of accumulated water, and expediting the circulation of steam. The boiler was recovered with 85% magnesia. The pitch pine fuel was tossed out and coal brought in. New radiation was hooked on to ameliorate cold spots although before this was considered impossible.

One of the major treatments used in this case, the dripping of the steam headers, seems to be almost a specific for many of these old one-pipe systems. Too often, one-pipe headers appear to have entirely too much radiation hooked to them for the de-watering facilities provided. The cure for this condition is, of course, the attachment of the drip pipe at a strategic point.

Another ailment frequently observed on old systems of all kinds, and which miraculously did not exist at Winter Haven, concerns the non-functioning and malfunctioning of radiator vent valves. Twenty years of service can foul them utterly. If this is not enough to affect system operation, then there is the number of such valves found in the wrong place. No doubt well-meaning persons, seeking to bring steam into a cold radiator, concluded that a valve at the bottom of the radiator will work when the one at the top failed.

In contemplating or undertaking any church job, we must remember that, despite the unprecedented prosperity of the past few years, money is still of prime importance to almost all congregations. If our memories fail in this particular, we soon enough shall be reminded. The effect, of course, is to complicate our problem, but at the same time to develop our ingenuity of design. For each of us, this last is pure gain, and should enable us to add to our accomplishments.

Methods of Joining Pipe

Screwed Joints for Ferrous and Brass Pipe

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First of a group of articles which will present engineering data on the various methods employed for joining ferrous and non-ferrous pipe.

PIPING systems using the best of materials but with incorrectly designed or poorly constructed joints will be a constant source of trouble and expense, and while it is common practice when writing specifications to place the responsibility on the contractor for installation of joints which will remain tight for a period of at least one year, the reputation of an engineer will suffer if an excessive amount of servicing by the contractor is required because of joints which do not remain tight.

To design and construct a satisfactory piping system, it is necessary for both engineer and contractor to have a thorough understanding of the many types of pipe joints available, and the advantages and disadvantages of each type for application to pipe lines constructed of many materials for many classes of service.

Reasons for Installation of Pipe Joints

Piping systems may be designed and installed for conveying liquids, vapors, or gases having a vast variety of physical and chemical properties and at a wide range of pressures and temperatures. In some cases the systems may be very short and simple and in others they may be very long and very complex. In any case it will be probably necessary to provide some form of pipe joints, for one or more of the reasons listed:

(1) Length of system may exceed the maximum length of a single piece of pipe which can normally be purchased, or which can conveniently be transported to the installation site or easily handled at the installation location.

(2) Changes in direction of the piping run may be necessary to permit an orderly piping arrangement to suit the general design of the building or to avoid interferences with equipment or other piping.

(3) Several pieces of equipment may connect to the system, and large mains with several branch connections become necessary.

(4) Proper operation of the system requires that valves, traps, strainers or other adjuncts to the system be installed.

(5) The same material is not used throughout the length of the system.

(6) Frequent inspection or cleaning of the system may be required, and joints provided that permit ready access to the interior of the system for inspection, or for complete disassembly for cleaning.

(7) System may be only temporary, subject to frequent changes or to removal and reinstallation to some other site within a short time after its installation. Therefore, it should be easily taken apart.

(8) Temperature changes may cause appreciable expansion and contraction in the system. Expansion joints must be installed to take care of such linear changes.

(9) Underground mains or mains laid on the surface of the ground may require special forms of joints at frequent intervals to permit piping system installation in a manner to conform to the terrain or to avoid obstacles such as large rocks and tree stumps.

(10) Special types of joints may be required to provide for settlement of the piping after it is in place, because of unstable soil conditions or to make allowance for settlement of a building to which it is connected.

(11) Swing joint may be required to permit free movement of one end of the system over a predetermined path. One such example would be a filling connection for trucks or tank cars.

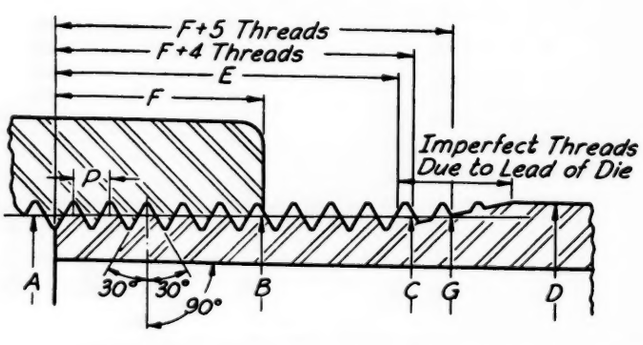


Fig. 1. American standard taper pipe thread. *A* pitch diameter at end of male thread; *B* pitch diameter at end of female thread; *C* maximum pitch diameter of straight male locknut thread; *D* outside diameter of pipe; *E* length of effective thread; *F* normal engagement by hand between male and female thread; *G* minimum pitch diameter of straight female locknut thread; *P* pitch of thread.

Selection of Type of Pipe Joints

Type of pipe joints to be used in any system will depend on numerous factors. Some of these are:

(1) Type of service for which the piping is to be used.

(2) Temperature and pressure conditions under which system will operate.

(3) Size of piping in the system.

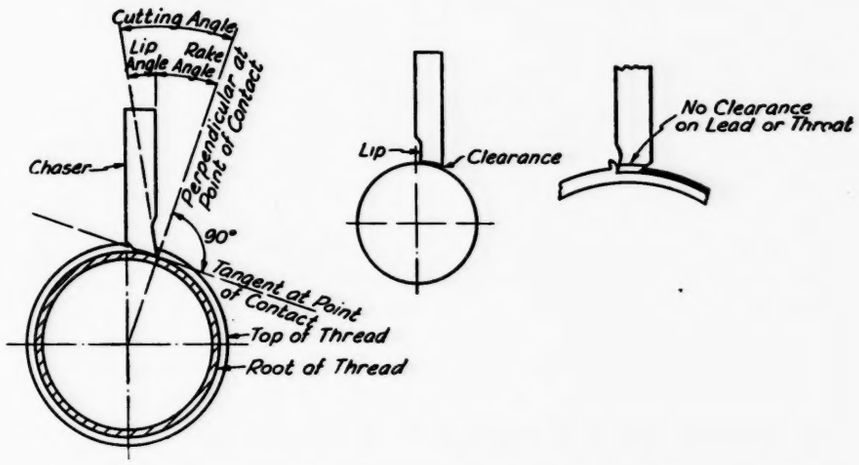
(4) Material of which piping system is to be constructed.

(5) Location of pipe section in which joint is to be installed.

(6) Anticipated time interval joints will remain undisturbed.

(7) Kind of labor available to install the joints and to service them when necessary after installation.

(8) Hazards involved by use of joints under consideration, either at the time of installation or after the system is in operation.



No. 2. Position of chaser in relating to pipe being threaded.

(9) Possibility of operating troubles due to faulty construction of joint.

(10) Possible adverse effect of temperature changes on the joint.

(11) First cost of installation and probable maintenance cost.

(12) Ability to repair joints without shutting down the system.

Where it is not possible to make repairs without shutting down the system, it will be necessary to consider how serious a shut-down would be, and the probable length of time of shut down required. When estimating the period of shut down, consideration must be given to the necessity of waiting for materials and suitable labor; the time required for draining, purging or cooling down the system before repairs can be made; the time required to make the repairs.

Screwed Joints

Screwed joints are the most commonly used for smaller sized lines at low and moderate pressures and temperatures where steel, wrought iron or brass pipe are installed.

They can also be used for other materials including cast iron, thermoplastic and wood piping.

Such joints do not create any special fire or explosion hazards during their construction; damage to valve seats; or plugging of small orifices by particles getting into the piping system as may be the case with welded joints. They are not appreciably affected by changes of temperature, as is the case with poured lead joints.

Chief disadvantages, however are the weakening of the pipe at the point where the joint is made and the greater liability to corrosion of the protective surface as galvanizing is cut in threading the pipe.

This type joint consists of threaded male and female ends screwed together, and as in the past, competent mechanics, high grade tools, and a vast variety of sizes and types of fittings, valves and accessories with screwed ends have been available, screwed joints have given satisfactory service without excessive cost.

A few years ago the use of screwed joints for valves and fittings on low pressure lines up to 12 in. dia. was commonplace, but in later years this was reduced to 8 in. dia. Today it is common practice in many plants to limit the size of screwed joints to that of 4 in. dia.

Screwed flanges are, however, still used for larger pipe sizes. They can be joined to the pipe in the shop or on the bench where they can be handled more conveniently.

In many installations the use of smaller sizes of steel, wrought iron, and brass pipe, with screwed valves and fittings is being discontinued. Copper tubing with a wall thickness less than the minimum required to permit threading, is used and for such cases other forms of joints are desirable.

Perfection that has been attained in the threading of piping materials is to a considerable extent due to the adoption and rigid adherance to the American Pipe Threads Standards by the entire piping industry.

Primary responsibility for the tightness of pipe joints is commonly assigned to the contractor. This is fair practice, as the contractor hires the mechanics, furnishes equipment for threading the pipe and making up the pipe joints and he should be in a position to control the grade of work which is turned out by his employes.

It is desirable, however, that the engineer as well as the contractor should understand the fundamental requirements for making screwed joints which are tight when the system is put in operation and which should remain tight in service.

Pipe Threads

Fig. 1 illustrates the correct manner in which steel, wrought iron or brass pipe should be threaded to suit the American Standard Taper Pipe Thread Specifications. Pitch diameters for this thread are determined by the formulas:

$$A = D - (0.050D + 1.1)P$$

$$B = A + 0.0625N$$

where A = pitch diameter of thread at end of pipe.

B = pitch diameter of thread at gaging notch.

D = outside diameter of pipe.

F = normal engagement by hand between external and internal threads.

P = pitch of thread.

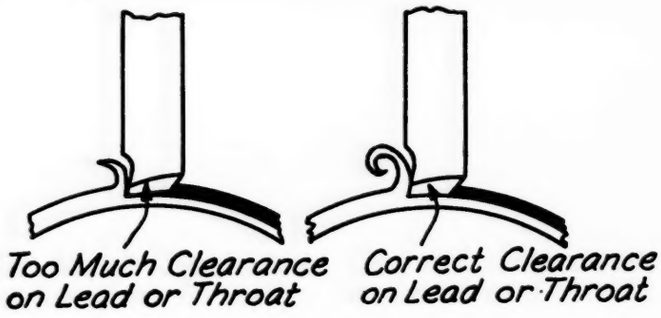


Fig. 3. Incorrect and correct clearance.

The thread has an angle of 60° between sides, and crest and root are truncated an amount equal to 0.033P. The depth of the thread, therefore, is 0.80P. For all practical purposes the crests on commercially manufactured threads are sharp, while the roots are practically sharp when cut with new tools and slightly rounded when cut with worn tools.

The pitch of the thread is the distance the axis will advance in one revolution, that is 1/n where n is the number of threads per inch.

The taper of the thread is 1 in 16 measured on the diameter, i.e. a change in diameter of ¾ in. per foot of thread length.

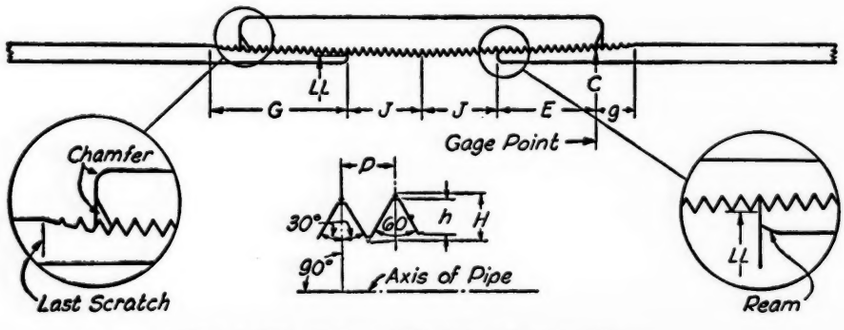
The length of effective thread *F* is determined by the formula:

$$F = (0.80D + 6.8)P$$

This length includes two threads slightly imperfect on the crest.

Outside diameters of standard pipe and extra strong pipe up to and including 12 in. dia., and double extra strong pipe up to 8 in. dia. (which is the largest size made) are the same. The same taps and dies can be used for threading pipe and fittings for these three grades of pipe.

In the oil fields, American Petroleum Institute (API) line threads are used. For sizes ⅛ to 1½ in. inclusive and 3 in., threads are identical with the American Standard Pipe Threads, but in other sizes the thread is longer. The extra length is at the small end. As the taper, number of threads per inch, etc. are the same for both standards, it is possible to use valves and fittings tapped with American Standard Pipe Threads in connection with API pipe providing no obstructions in the thread chambers are present to interfere with the longer API thread.



No. 4. Thread specifications for couplings.

Drive well pipe, which is made in sizes 1 in. 1¼ in. and 1½ in., and drive pipe, have greater total length of thread and length of perfect thread than API line pipe. The form of thread differs from the API thread as the tops and bottoms of the threads are rounded.

API drill pipe and interior upset rotary pipe are upset internally at the ends. Threads for drill pipe are rounded at the top and bottom and the total and effective lengths of thread for each of these forms of pipe are much longer than the nearest corresponding sizes in API pipe.

API casing threads have the same form of thread as American Standard Taper Pipe Thread but the pipe diameters do not correspond.

There are other forms of casing threads which differ from the API standard in the number of threads per inch, included taper per foot, and the effective length of thread.

British Standard Pipe Threads have a 55° angle of thread and greater length of effective thread than American Standard Pipe Threads.

Plumbers' Tubing

Plumbers' tubing has much thinner walls than standard pipe and finer pipe threads are used as indicated in Table 1.

Table 1 — Comparison of Standard and Fine Threads

Nominal in. dia. of pipe or tube.....	½	⅝	¾	⅞	1	1¼
Tubing threads per in.	28	20	20	18	18	18
Pipe threads per in...	14	....	14	....	11½	11½

Hose Threads

There are many standards for hose threads and it is necessary when ordering material for use with hose lines to specify the threads to be furnished. The number of threads per inch and the service recommendations for hose connections are given in Table 2 and 3.

If either of these standards are specified, no further information is required and manufacturers can usually supply hose valves with the proper special threads for the major cities without difficulty if advised of the location in which they are to be used.

Good clean cut uniform threads make tight strong joints, eliminate leaks, extend the life of the installation and result in complete satisfaction with the fabrication and the piping material.

Carelessly cut, wavy, shaved or rough threads result in a weakened piping system, localization of corrosion, high maintenance cost, and condemnation of the workman and the piping material.

Before threading pipe it should be cut squarely to the required length and the ends reamed to remove all burrs caused by cutting.

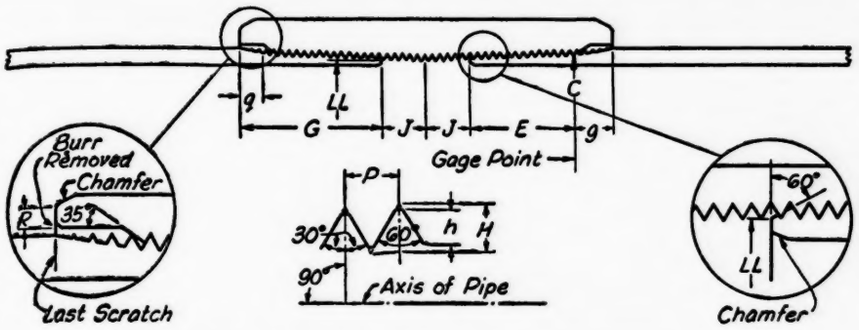


Fig. 5. Couplings for high pressure service.

Table 2 — American Standard Hose Coupling Screw Threads

Nominal Size Inches	Service Recommendations	No. of Threads per In.
½	Garden and similar hose	11½
⅝		11½
¾		11½
¾	Chemical engine and booster hose	8
1	Fire protection hose	8
1½		9
½	Iron pipe hose threads for steam, water, oil and all other hose connections	14
¾		14
1		11½
1¼		11½
1½		11½
2		11½

Table 3 — American (National) Standard Fire Hose

Nominal Size Inches	Service Recommendations	No. of Threads per In.
2½	Fire hose coupling screw threads	7½
3		6
3½		6
4½		4

Pipe threads are usually cut with dies or chasers and if these dies are of poor design, are badly worn, or improperly ground, poor threads will result. To secure sound joints it is necessary to have clean smoothly cut threads of the proper pitch or lead, taper, thread form and size. To cut such threads it is necessary to have threading dies and die heads made with proper consideration of lip and cutting angles, lead or throat, chip space, clearance and number of chasers. In addition, it is necessary to use a suitable grade of threading oil and to have equipment in good operating condition, with clean chaser slots, and the thumb screws of die stocks well tightened.

To cut metal smoothly with an edged tool a certain angular relationship must be maintained between the cutting surface of the tool and the surface of the metal being cut. In cutting threads on pipe this angle, known as the cutting angle, varies somewhat with the character of the pipe metal and may be obtained by several different methods.

In Fig. 2 is shown the position of the chaser in relation to a pipe which is being threaded, and the relation between the cutting angle, lip angle and rake angle.

The lip is a slanted cutting surface on the chaser which allows the chips to curl off clean and leave a smooth thread. It also gives an easy cutting action to the chaser, similar to that of a properly ground lathe tool, instead of the pushing effect obtained with chasers having insufficient cutting angle.

The rake angle is the angle which the front edge of the chaser makes with the perpendicular at the point of contact.

The cutting angle is the sum of the lip angle and the rake angle. Correct cutting angles vary with different materials, and pipe manufacturers' recommendations should be followed. There are many undesirable consequences of using dies not having the proper cutting angle. One of the most serious is wavy or crooked threads. In addition, the extra power required to force the dies has a tendency to break out the teeth, which then pick up "stickers", tearing the tops from the threads and creating unnecessary friction.

Lead is the angle which is machined or ground on the first three threads (more or less) of each chaser to enable the die to start on the pipe and also to distribute the work of making the cut over a number of threads. The proper amount of lead is about three threads. As the heaviest cutting is done by the lead it should have slightly greater clearance angle than the rest of the threads on the chaser, but care must be used to see that this angle is not excessive. Too much clearance will cause the die to lead too fast, and the half threads cut by the lead will be damaged by the full teeth of the chasers.

Clearance

Clearance is the distance between the threads on the chaser and the threads on the pipe at a given dis-

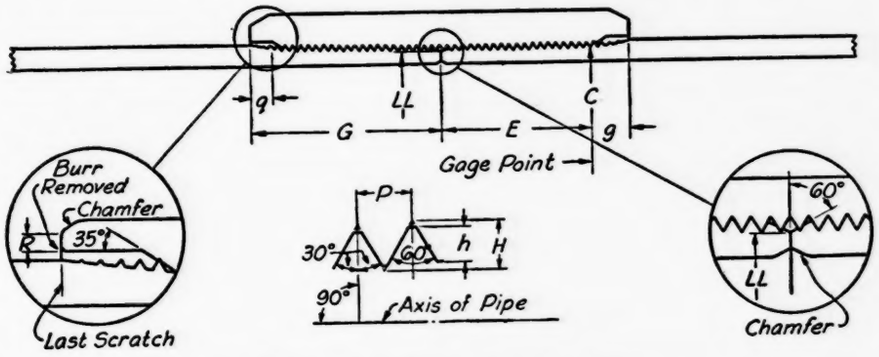


Fig. 6. Couplings for drive pipe.

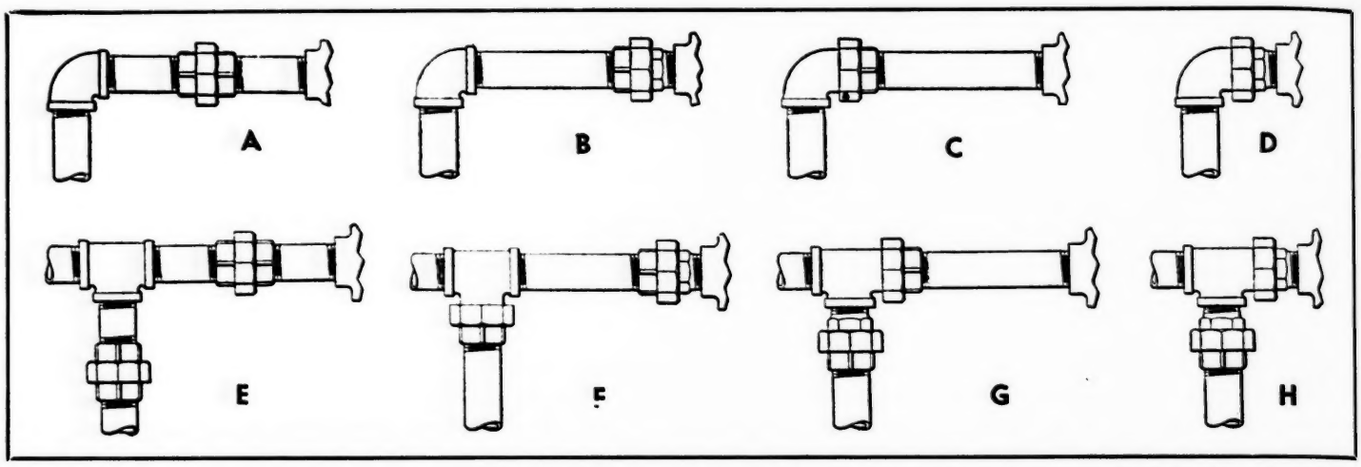


Fig. 7. Elbow and tee connections with union joints. A, 1 piece of pipe, 2 fittings, 5 pipe threads, 6 joints assembled; B, 2 pieces of pipe, 2 fittings, 1 pipe thread, 5 joints assembled; C, 2 pieces of pipe, 1 fitting, 3 pipe threads, 4 joints assembled; D, 1 piece of pipe, 1 fitting, 1 pipe thread, 3 joints assembled; E, 5 pieces of pipe, 3 fittings, 8 pipe threads and 10 joints assembled; F, 3 pieces of pipe, 2 fittings, 4 pipe threads, 7 joints assembled; G, 3 pieces of pipe, 2 fittings, 4 pipe threads, 7 joints assembled; H, 2 pieces of pipe, 2 fittings, 2 pipe threads, 6 joints asssembled.

tance from the cutting edge as shown in Fig. 3. Greater clearance is required for hard material than for soft material. With ideal clearance the sides of the threads become polished, brighter at the cutting edge, and gradually shading almost to their original color at the back. The chaser which shows this condition will work freely, will cut cleanly, will not tear the thread and will be durable.

Oil for Cutting Threads

Care should be used in the selection of a suitable threading oil, as the best die made will not produce good results with poor or insufficient oil.

Since oils used in threading operations serve more than the function of a lubricant, the oils should be selected for their cutting quality and not for their lubricating quality. Any good cutting oil has sufficient lubricating qualities, but the best lubricating oils may be worthless so far as facilitating the cutting action of the chasers is concerned.

For cutting action there is probably nothing better than No. 1 Lard Oil but the cost will naturally prevent its general use. There are a number of cutting oils on the market at the present time which are giving satisfactory results. Most of these derive their value from the fact that they have a high sulphur content which has a desirable cooling effect on the dies.

Where power machines are used an ample flow of oil should be provided so that the dies will be kept flooded at all times. This assists in keeping the dies cool and helps to prevent their becoming clogged with chips.

Classification of Screwed Pipe Joints

Screwed pipe joints may be divided into three classifications:

(1) Pipe to pipe. This type joint is required where it is necessary to install a section of pipe between equipment valves or fittings, and the run is longer than desirable or practical for a single continuous length of pipe.

(2) Pipe to fittings. This joint is required to permit change in direction or size of pipe, or to provide a means for branch connections to the system.

(3) Pipe to equipment or valves, as required for proper operation of the system.

Pipe to pipe screwed joints are made with either couplings, screwed, or screwed flange unions.

Screwed fittings include elbows, tees, crosses, 45°, Y-branches or laterals, return bends and reducers in various patterns, sizes and weights. As far as making up a joint is concerned, they are essentially the same. There are, however, four distinct classes of joints for screwed fittings, as shown and described later on under the heading "Fittings."

Equipment and valves in general require joints similar to those used with fittings which are tapped for American Standard Pipe Threads.

Couplings

For normal requirements, couplings are threaded with right-hand thread for the full length, and have plain ends. When the joint is made up, the ends of the pipe do not touch, and the imperfect threads on the pipe are not covered by the coupling, as shown in Fig. 4.

When it is necessary to install a piece of pipe to close the space between two sections of pipe already in place, without using a union or flanges, one end of the filler piece is threaded left-hand and the coupling is threaded with one end right hand and the other with left hand thread. This makes it possible to screw the coupling on the ends of the two adjacent pieces at the same time to make a tight joint.

Couplings for high pressure service, for service where the piping is subject to shock as in hydraulic systems, and for use on API line pipe, drive pipe, and well casings, have the ends of the couplings recessed to cover the imperfect threads on the pipe, as shown in Fig. 5.

While this does not strengthen the joint it does protect the thread somewhat better against dirt and moisture and, therefore, probably reduces the danger of corrosion.

Couplings for drive pipe are so threaded that when a joint is made up correctly the ends of adjacent sec-

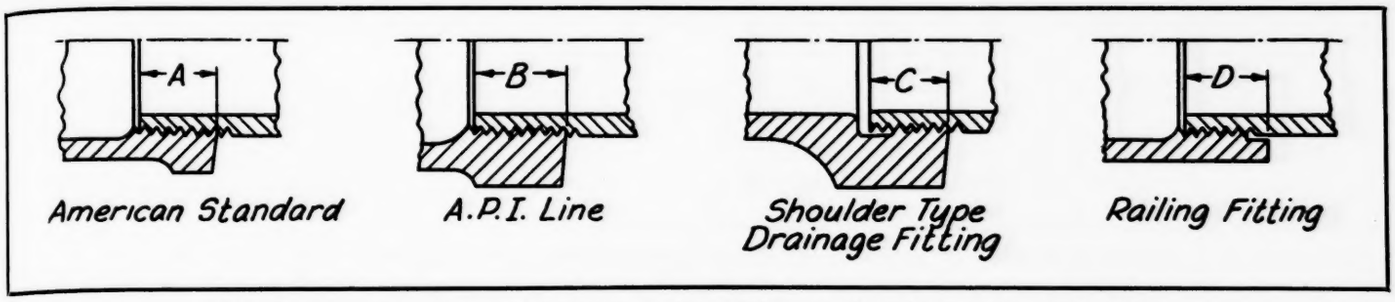


Fig. 8. Normal engagement between male and female threads to make tight joints.

tions of pipe are butted, as shown in Fig. 6. This reduces strain on the pipe threads when the pipe is being driven in place.

Unions

Unions consist of three pieces, and where used for connecting two adjacent pieces of pipe, they have female ends threaded for American Standard pipe threads, unless otherwise specified, and the collar piece has a straight thread. The joint between the two adjacent sections may be designed for use with a gasket, or for metal to metal contact. Gasket type unions commonly have square surfaces with a lip on the inside edge of one of the sections to keep the gasket in place. Gaskets may be of rubber for use with steam up to 150 lb pressure or with cold water up to 300 lb pressure. For severe service, forged steel unions having bronze or steel gaskets may be used.

Unions without gaskets may have beveled male and female adjoining surfaces, with seats all iron, all steel, iron or steel to bronze, or bronze to bronze. Where gaskets are not used, it is desirable that unions should have the seating surfaces ground to insure tight joints.

Unions with one male end and one female end provide a simple means of making a joint to equipment which must frequently be disconnected, and which is not equipped with flanged connections. Union elbows and tees are sometimes used to advantage to reduce the number of joints in a piping system.

Before making up screwed joints it is important that the threads on both the pipe and the fitting or valve into which it is to be inserted are clean and in good condition. Any threads which may have become burred or bent should be straightened, and afterward a good grade of lubricant applied to the male thread only. The lubricant reduces the friction, allows the two parts to be pulled up closer, resulting in a more effective pipe joint. Pipe joints should not be screwed together too rapidly to avoid objectionable temperature increase of the two parts.

The relation between pipe and fitting and a comparison of the normal engagement between male and female threads on four types of screwed joints is shown in Fig. 8 and Table 4.

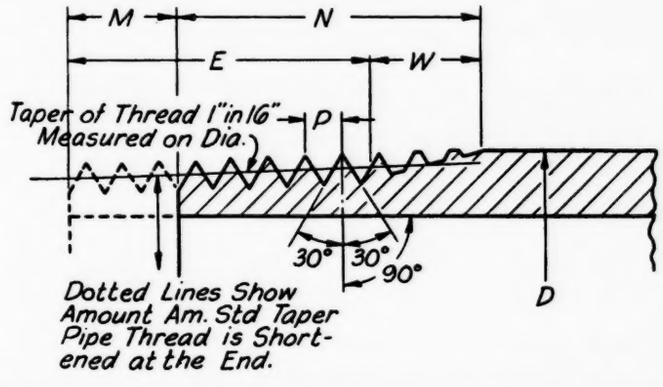


Fig. 9. External taper pipe threads for railway fittings. See Table 5.

Table 4 — Normal Engagement of Pipe Threads

Type Joint	A	B	C	D
Size of Pipe	Length of Engagement, Inches—See Fig. 8			
¼	⅜	⅜		
½	½	½		½
¾	9/16	9/16		½
1	11/16	11/16	9/16	⅝
1½	11/16	11/16	⅝	¾
2	¾	15/16	⅝	¾
3	1	1	15/16	1 1/16
4	1¼	1¼	1 1/16	1 3/16

From this table it is apparent that in most pipe sizes the normal thread engagement required to make a tight joint is the same for API Line Pipe Threads, and American Standard Pipe Threads except for 2 in. dia. pipe. This is the only size line pipe that differs in length of thread from the American Standard. The regular thread chambers in the lower pressure fittings and valves do not accommodate this larger line pipe thread.

Thread engagements given for recessed or shoulder type drainage fittings will provide a tight joint and will insure that the end of the pipe comes reasonably close to the shoulder in the drainage fitting.

Threads in railing fittings are recessed and are shorter than threads in pressure fittings. Railing fittings are tapped to make satisfactory mechanical joints of ample strength if male pipe threads as shown in Fig. 9 are used. These male threads can be cut and gaged with standard equipment.

Where valves, fittings, or flanges are required for casings with long threads such as API, DBX (California Diamond BX casing—10 threads per inch) and DB8 (California Diamond B8 casing—8 threads per inch), it is necessary either to shorten the thread on the casing or to tap the valve or fitting to a smaller size thread in order to prevent the end of the casing coming in contact with internal parts of the valve or

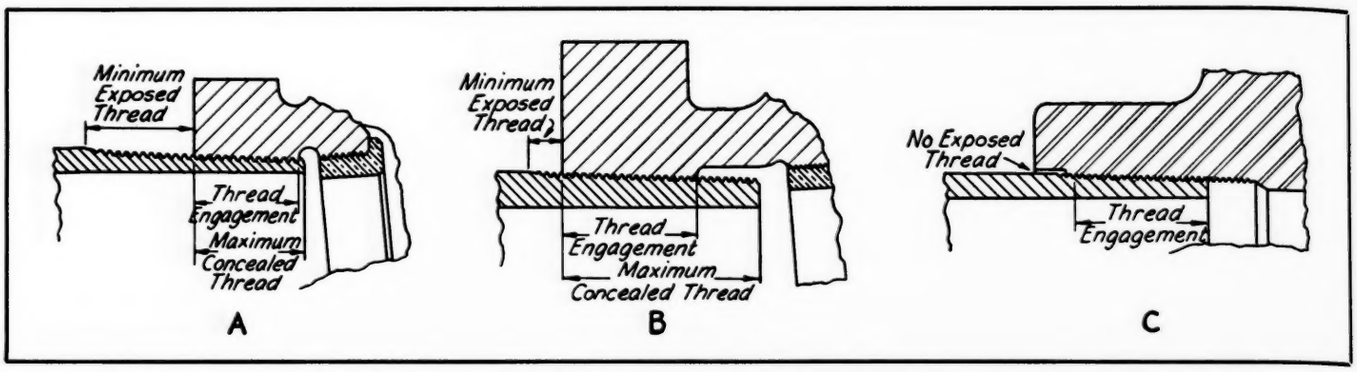


Fig. 10. Valve casing thread assembly. A, for standard 125 lb valve; B, for extra heavy 250 lb valve; C, drilling through valve.

Table 5 — Dimensions of External Taper Pipe Threads for Railing Fittings

(See Fig. 9)

Nominal Pipe Size Inches	D Outside Diameter of Pipe Inches	Number of Threads per Inch	Depth of Thread Inches	Y Pitch Diameter at End of External Thread Inches	E Length of Effective Thread of Am. Std. Pipe Thds. Inches	N Total Length of External Thread, Inches Max.	M SHORTENING OF AM. Std. Pipe THREAD		W IMPERFECT THREADS DUE TO LEAD OF DIE MAX.	
							Thds.	Inch	Thds.	Inch
½	0.840	14	0.0571	0.7718	0.534	0.498	3	0.214	2½	0.179
¾	1.050	14	0.0571	0.9811	0.546	0.510	3	0.214	2½	0.179
1	1.315	11½	0.0696	1.2299	0.683	0.639	3	0.261	2½	0.217
1¼	1.660	11½	0.0696	1.5734	0.707	0.707	3	0.261	3	0.261
1½	1.900	11½	0.0696	1.8124	0.724	0.724	3	0.261	3	0.261
2	2.375	11½	0.0696	2.2853	0.757	0.757	3	0.261	3	0.261
2½	2.875	8	0.1000	2.7508	1.138	1.013	4	0.500	3	0.375
3	3.500	8	0.1000	3.3719	1.200	1.075	4	0.500	3	0.375
3½	4.000	8	0.1000	3.8688	1.250	1.125	4	0.500	3	0.375
4	4.500	8	0.1000	4.3656	1.300	1.175	4	0.500	3	0.375

fitting before making a tight joint in the threaded end along the taper, as shown in Fig. 10.

While it is possible to make pipe joints that are tight due to proper mechanical contact between the male and female threads, it is common practice because of imperfections in materials, the use of improper threading equipment, or lack of skill on the part of mechanics, to rely on the application of joint compounds between the male and female threads, to insure tight joints. For many installations the use of a mixture of lead and linseed oil has proved satisfactory for this purpose.

There are also several prepared compounds on the market which are apparently giving satisfactory results. One reputable manufacturer advertises that his product withstands gasolene, oil, butane, propane, Freon, air, water, steam, acid, gas or brine, and that it lubricates and completely seals pipe joint threads.

Other manufacturers stress the fact that their compound seals joints tightly and lasts indefinitely, but always leaves the pipe joint easy to take apart. Claims for some compounds are that they are free from lead or lead substitutes which might affect the taste or odor of potable liquids.

For distilled water lines in laboratories it is very necessary to avoid any possibility of water contamination by use of compounds containing lead or other objectionable material. When preparing specification for such installations, or before making the installation, it is advisable to check with the chemist in charge of the laboratory regarding any compound it is planned to use.

Where screwed joints are used on oil lines, a mixture of litharge and glycerine will provide a tight joint, but it is difficult to disconnect a joint that has been made up in this manner, if that becomes necessary. An alternate material for use on oil lines is glyptol lacquer or varnish.

A mixture of beeswax and turpentine has been used successfully for sealing joints on vacuum lines where the ability to maintain vacuums of approximately 30 in. for extended periods is necessary.

Where any material subject to combustion is used for making up joints in oxygen lines it is essential to thoroughly clean the line before using to prevent fire and possible explosion due to rapid oxidization of any of the compound that may be left on the inside of the pipe. Although piping may be cleaned by thoroughly steaming out, after erection, it is better to follow this treatment with a hot water solution of caustic soda or tri-sodium phosphate, before placing the line service.

In some sections of the country the practice of wicking joints is common. Strands of wicking as required are wrapped around the pipe at the bottom of the thread to act in the same manner as a gasket. While this is one method of making a tight joint it cannot be regarded as desirable.

Welding by the Inert-Arc Process

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This form of welding, either as a manual or a machine process, can be applied for the rapid welding of stainless alloys, copper alloys and aluminum.

INERT-ARC welding is a process which uses a non-consuming electrode to hold an arc in an atmosphere of inert gas.

Inert-Arc is a term used to designate a fusion welding process which utilizes inert gases (helium and argon) to shield the tungsten electrode and molten metal from the atmosphere. As early as 1940, helium gas was used to shield welds made on magnesium. The process has now been extended to aluminum, copper, and stainless steels. Results obtained by the application of this process are continually surprising to persons who have been active in its development.

The most valuable gain made by its use is the elimination of flux for welding any type metal. Being an arc welding process, it is faster than gas welding and by excluding the air from the weld sound, ductile and bright welds are obtained.

Of the metals being welded today only aluminum requires the use of alternating-current and argon gas. Actually, aluminum has been welded successfully by using argon gas and direct-current reversed polarity, but several problems arise which make it more practical to use alternating current.

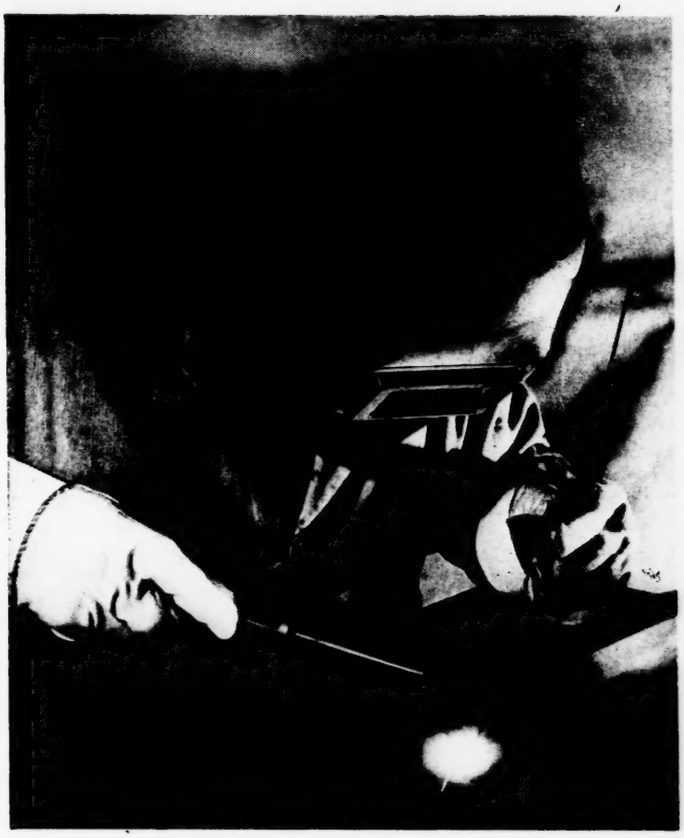

Fig. 1. Light gauge plate being manually welded by the helium-shielded arc-welding process.

Gases Used in Process

Usually it is standard practice to use either argon or helium gas, utilizing their different characteristics to get the best results. Except on alloys such as aluminum, and very thin materials, helium is preferable to argon because helium produces more heat per ampere of welding current, other factors being equal. This applies to the welding of inconel, copper, and stainless steel when direct-current straight polarity is used. When magnesium is welded, then direct-current reverse polarity is used.

The arc voltage with helium is higher than the arc voltage with argon. Since heat in the arc depends on arc voltages as well as arc current, helium will produce more heat than argon and travel speed can be increased for the same current flow. If travel speed is increased, then welding time is cut down, and even though the rate of helium flow would be greater (because of its lightness) than argon. Total gas consumption will be such as to make helium the more economical gas on most applications.

This characteristic of higher heat for helium than for argon, using the same current, becomes a disadvantage when welding very light gauge metal about 1/32 in. thick. Here arc stability becomes a very serious factor. For a certain heat in the arc and the same travel speed, the arc in helium would require less current than argon. Since it is advantageous to use the highest current possible on small electrodes in order to have good arc stability, it then becomes better to use argon than helium provided the finished welds in either gas are of equal quality.

Arc length, another factor to consider, can be changed when welding in argon without appreciably changing the heat input to the work. Therefore, arc length is less critical when using argon. Fig. 2 shows that for a typical curve of arc voltage versus arc length, argon has a very flat slope curve. On the other hand, the arc voltage-arc length curve with helium has a very marked rise and is steep enough to permit an electronic panel to interpret changes in arc length by a change in voltage. Electronic panels now available will interpret arc voltage changes in helium, but not in argon. Therefore, all automatic machine welding applications are confined to the use of helium gas.

With helium gas it is not necessary to have an

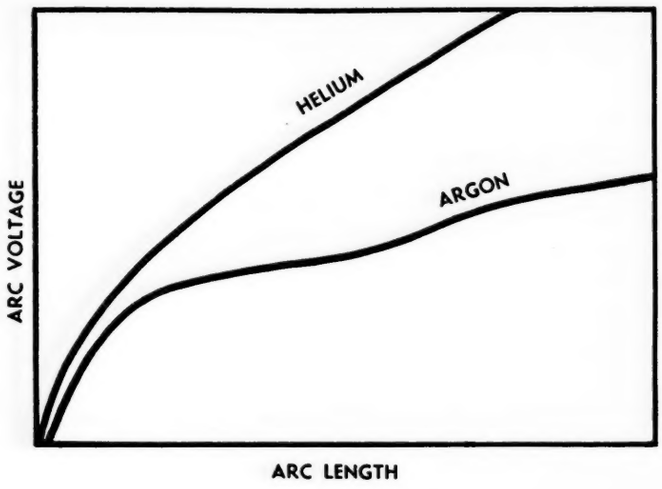

Fig. 2. Arc voltage vs. arc length in argon and helium.

elaborate fixture to hold the material to be welded at a certain point under the arc. In fact, machine welds can be made on contours which are irregular in shape for the electrodes can follow the seam very accurately by electronic control.

Semi-automatic operation can be performed in either atmosphere if the seam is of such contour as to require little or no adjustment of the electrode during welding.

The versatility of the process has been demonstrated by welding many metals including magnesium, stainless steel, aluminum, copper alloys, molybdenum, tungsten, gold, and silver. Of these, stainless steels, aluminum, and copper alloys are most widely welded by this process. Let us now discuss each of these groups in a little more detail.

Stainless Alloys

The most common stainless alloys used today are the so-called 18 and 8 alloys—18% chrome, 8% nickel —and they present very few problems from a welding standpoint. Excellent welds can be made by oxy-gas, atomic-hydrogen and metal-arc welding, as well as with the inert-arc process. There is one outstanding advantage to be gained by the latter process. Because of the arc concentration and the rate of welding, the heat-affected band of base metal adjacent to the weld is much narrower. This results in better corrosion resistance in and around the weld, especially in the straight chrome-nickel alloys.

Direct-current, straight polarity, and argon or helium gas are used in most stainless applications. The manual technique differs from other processes in that manipulation of the arc is seldom necessary. Generally, the speed of travel is uniform, and when required, the filler material is added as in the atomic-hydrogen or oxy-gas processes. The arc presents a soft sound with no spatter. As mentioned, no flux is required for welding stainless materials with this process. This eliminates the mess encountered when using flux, and prevents the possibility of corrosion from flux which is not removed after welding.

Stainless materials are being welded in thicknesses from 10/1000 in. to 5/16 in. without the necessity of beveling.

Copper Alloys

Although less work has been done on copper than on other material, this application gives promise of being one of the best. Here again, direct current, straight polarity is generally used with a helium gas shield. Excellent results have been obtained on deoxidized copper, silicon bronze, phosphor bronze, and beryllium copper.

While there are several reasons why this process is desirable for copper alloys, one of the most important, as with other materials, is the elimination of flux. By completely protecting the arc and the molten metal from atmospheric influence, the formation of harmful compounds is avoided. It has been suggested, also, that by providing an inert atmosphere around the molten crater, the reducers present in the alloys are able to reduce some of the oxides which have been formed in and on the metal during other processing.

Shielding the arc by a helium or argon atmosphere also results in sounder welds than can be obtained by the carbon arc process or by the metal arc process. In fact the soundness and ductility of welds in the copper alloys mentioned, obtained by the inert-arc process, are equal to those obtained by the oxy-acetylene process.

This brings up another advantage which makes the inert-arc preferable to the oxy-acetylene process speed. Because of the high temperature and concentration of the arc, the metal is quickly melted, and rapid progress can be made in welding. Because of this hot arc, preheating can be greatly reduced, and for materials less than ¼ in. thick, pre-heating can be eliminated. Since the arc is concentrated in a small area, it is possible to get excellent penetration. Reasonable speeds have been obtained when welding a ½ in. thick silicon bronze square butt joint. Elimination of the bevel saves machining cost and largely reduces the amount of filler metal required.

Still another advantage of the process is its relative simplicity. To set up for automatic or semi-automatic operation generally requires less complicated equipment than is used with other processes. For manual welding, the technique is easily acquired, since factors concerned with technique, such as arc length and speed, are not as critical as they are in other processes. Because of such latitude, it is possible to weld butt joints in copper strips as thin as 10 mils, and as a result of this simplicity, it is comparatively easy to make welds of excellent appearance.

Welding Aluminum

One of the most popular applications of this process has been for welding aluminum. For work on aluminum with no flux, argon is the gas used in commercial application. Welds with this inert-arc process are clean, bright, and exceptionally sound. Alternating current is used with the proper circuit to provide a stable arc in an atmosphere of argon gas without using flux.

However, when an alternating current circuit is used on aluminum, a characteristic of aluminum oxide termed rectification is observed. Rectification is the name given to the action of the aluminum oxide which hinders current flow in one direction while permitting current to flow in the opposite direction. This rectification action causes a direct current to flow while welding. This direct current may be a large proportion of the total current in the circuit and will cause overheating of the welder primary and secondary circuits. It can be prevented from flowing by using storage batteries in series with the secondary of the transformer to buck out the direct current. Series capacitors also give the same results.

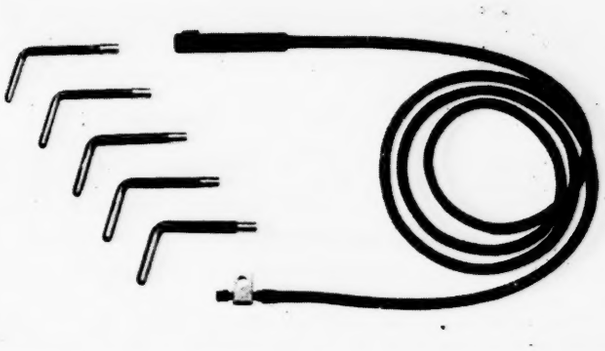

Fig. 3. Components of the gas shielded arc welding electrode holder. At the left are 5 clamps for electrodes.

High-Frequency Pilot Spark

For several years it has been known that welding arcs of low current density can be stabilized with the use of a continuous, intermittent high frequency, high voltage, pilot spark. One common method for obtaining this discharge has been with a high voltage discharge through a condenser and a spark gap. The spark gap is in series with the primary of an air core transformer whose secondary is one welding lead. This high-frequency circuit, to operate satisfactorily, has to produce a hot spark across the arc gap. The hot spark helps to ionize the arc gap to make it easier to weld with low current. This type of circuit has been used in the past in metal arc welding of thin material. An auxiliary use of this high frequency has been to start the arc on a given spot on the work without touching the electrode.

There are some advantages of this circuit in its application to inert-arc welding. Although the high-frequency arc jumps a gap several times a second, it is commonly called continuous high frequency if the high-frequency circuit is energized at all times. If continuous high frequency is used, a clean pool can be obtained when welding with argon on aluminum with low open circuit alternating voltages such as are found in metal arc welding. Although clean welds are obtained, the direct current component is still present and may result in the disadvantages noted.

There are some other disadvantages to the use of continuous high frequency pilot sparks in inert-arc welding. Most pilot spark designs utilize frequencies which are within the broadcast band wave length. This means that every continuously-operating, high-frequency pilot spark is a small radio station which sends out static in every direction. It is hard to shield this high-frequency source, and consequently a great deal of radio interference may occur. The maintenance on a continuously operating high-frequency pilot spark is quite excessive, and continuous adjustment of the spark gap may be necessary.

An inert-arc welder with a built-in high-frequency pilot spark unit has been designed to weld aluminum. The sole value of this high-frequency unit is to start the arc without the need of touching the electrode to the work. By water-cooling the pilot spark equipment, it can be built to operate at a frequency below the broadcast band and still be small and compact. This high frequency is automatically disconnected from the circuit by a relay when the power current flows in the arc. This very intermittent use of the high-frequency pilot spark coupled with the fact that it has a frequency below the normal broadcast band will minimize radio interference.

This unit does not depend on high frequency to weld. It has enough voltage to make the arc stable and blocks all direct-current flow with the use of series capacitors. These series capacitors, with the higher open circuit voltage, permit the unit to be used to weld aluminum without flux and to produce a clean, sound weld.

Technique

Unlike welding with oxy-gas and flux, a clean, bright puddle is established as soon as the arc is struck. The puddle is not concealed by flames and flux so that it is much easier for the operator to see and control the flow of metal. These characteristics of the process make it readily adaptable to position welding. Welds of excellent appearance and quality can be made with comparative ease in both the vertical and overhead positions as well as in the flat position. Material up to ½ in. thick has been welded without the necessity of beveling.

This technique is not unlike that used with oxy-gas welding except that in most cases with the inert-arc process no preheat is needed for welding. A right handed operator welds from right to left. Filler material is added with the left hand by "poking" the filler rod into the molten pool and withdrawing it quickly. Some operators prefer to use a smaller filler rod and feed continually into the puddle. One important point to remember regardless of the technique used is that the molten end of the filler rod should be shielded from oxidation. In other words, the end of the filler rod must be held within the shielding envelope of gas while the filler rod is hot or must be withdrawn quickly beyond the heat of the arc to prevent excessive oxidation.

In most cases, if the speed of travel is right, no arc manipulation will be necessary. The technique for flat and overhead position is not greatly different. Of course, it may not be quite as comfortable to weld overhead as flat, but no spatter is encountered so that some of the discomfort usually encountered in overhead welding is eliminated.

Technique in the vertical position is equally simple. Usually a steady arc can be maintained while the filler is added from the side, if there is room, or from the direction opposite to the travel. Excellent penetration can be obtained on material up to ¼ in. thick while welding vertically down. On thicker materials, or where heavy build-ups are required, welding should be done from the bottom up. Manipulation of the electrode and filler wire is about the same as in the overhead position.

Electrodes

Electrodes used in inert-arc welding are usually made of tungsten. Tungsten is used because of its very high melting point with respect to other metals.

Tungsten electrodes used in inert-arc welding are not consumed in the welding operation as are metal-arc electrodes, but some tungsten is consumed during the starting operation. By this it is meant that when proper welding conditions prevail the electrode consumption is negligible. Arcs can be started in several ways. Electrodes can touch the work as is done on metal-arc welding, or the electrode and the work can be touched simultaneously with a carbon starting stick, or a high-frequency pilot spark unit can be used to start the arc.

Summary

The inert-arc process will produce a sound, good-appearing weld at high speed on any application where a minimum of filler wire is to be added. It should be superior to most present welding methods for these applications. There is no common joint design on which the inert-arc process has not produced a satisfactory job. The process can be applied manually or with a machine, with or without automatic arc control. Argon gas is used to weld aluminum with alternating-current, and light gauge alloys with direct current straight polarity. Helium gas is used to weld magnesium with reverse polarity, and most other metals using direct-current straight polarity. This welding process can be used with excellent results on all types of non-ferrous pipes, authough not quite as good on carbon materials as other types of welding. The only equipment needed over and above that used with other types of welding is a cylinder of gas and regulators.

Inert-arc welding is in its infancy but its success has been so spectacular that to establish any limits for the process would be merely presumptive.

Use of Glycerine on Air Filters

Air filters for the removal of dust are usually moistened with a liquid to which the dust will adhere. When filled with dust, the filter must be washed, unless the throw-away type is used, and a fresh application made of the adhesive liquid. When this liquid is a petroleum oil, the dirty oil must be washed off either with a solvent or with soap and water. However, if the adhesive liquid is water-soluble, it can be easily and cheaply removed by rinsing with plain water.

Glycerine is a water-soluble liquid which has been successfully used on air filters. It is easily applied to the filter, effectively holds dust and is easily washed off with water. The glycerine may be used as an aqueous solution of approximately 50% concentration by weight (46-47% by volume), containing about 0.2% of dissolved glue or other viscosity-increasing substance. The solution weighs about 9¼ lb per gallon.

In some installations filters may be placed close to hot furnace pipes. Consequently, it is of interest from the standpoint of safety to know the flash and fire points of glycerine solutions. Tests were made with a Cleveland open cup, using the procedure described in Test D92-33 of the A.S.T.M. With the 50% glycerine solutions, it was necessary to add an extra portion of solution to compensate for the large amount of water evaporated during the heating of the samples. Results of the tests are given in the following table:

Flash and Fire Points of Glycerine Solutions

Initial Glycerine Concentration	Flash Point		Fire Point	
	F	Final Concentration	F	Final Concentration
99%	350	99.0%	400	99.4%
95%	375	97.8%	400	98.6%
85%	375	97.5%	400	98.6%
75%	375	97.5%	400	98.6%
50%	375	97.5%	395	98.2%
50% plus 0.2% glue	380	.....	395	.....

The flash and fire points of glycerine solutions were found to be largely independent of the initial concentration of the solutions. The more dilute solutions must concentrate by water evaporation to about 97.5% glycerine before the vapors will flash and to about 98.2% glycerine before they will burn. More concentrated glycerine (99%) flashed 25 degrees lower than the solutions did. All samples burned at 400F or within 5 degrees of that temperature. Addition of 0.2% of glue to the 50% solution did not significantly affect its flash and fire points.

The use of glycerine solutions on air filters does not, therefore, introduce an unusual fire hazard, since oils of similar flash point are used for the same purpose. —*J. B. Segur, The Miner Laboratories, Chicago, Ill.*

Hot Water Heating With Unit Heaters

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Proponents of hot water unit heater systems point to the success of existing installations to support their claims that the advantages are many; the disadvantages few.

WITHIN the past decade, the development of new and improved equipment and techniques for forced circulation hot water, and the acceptance by the contractors, engineers, architects and public of this heating medium for use in all types of buildings has increased enormously.

While most of the many forced hot water installations have been in dwelling units and offices, a considerable number of large industrial installations involving the use of unit heaters have been completed. In spite of the outstanding success of these installations, little information has been made available concerning their design and operating characteristics.

This may be at least partially due to the fact that practically all unit heaters have been designed for steam. The accepted criterion of a well designed unit heater has been its ability to deliver its rated Btu capacity with final air temperatures of from 100F to 125F with steam at two pounds and with 60F entering air. Special attention has had to be given to the design of these jobs, however, due to the fact that a good steam unit is not always a good hot water unit under usual operating conditions. For example, a unit which will deliver air at 111F with low pressure steam will deliver air at only 86F with 170F average water temperature.

A new line of unit heaters includes a series of models designed specifically for forced circulation hot water service. Their operating characteristics reflect an increase of approximately 36% in Btu output and as high as 17% in outlet air temperatures when compared to similar steam models. Resistance to water flow is decreased. The availability of these special hot water models will greatly improve the performance of any installation involving unit heaters with forced circulation hot water.

Proponents of hot water unit heater systems point to the success of existing installations to support their claims that the advantages are many; the disadvantages few.

They point out that installation costs are usually low. Expensive high pressure equipment is not required; pipe sizes are generally smaller (particularly when compared to a low pressure steam system); insulation requirements are simplified; and the necessity for expensive accessories such as boiler feed control equipment, pressure reducing stations, traps, strainers, and vacuum pumps is eliminated. The requirements for auxiliary equipment are usually reduced to a simple, relatively low-cost circulating pump and a few simple air venting devices.

Typical Unit Heater Performance with Varying Water Temperatures — 60F Entering Air

Outdoor Temp. F	Entering Water Temp.	Unit Designed Especially for Hot Water		Unit Designed for Steam	
		Btu per hr	Final Air Temp. F	Btu per hr	Final Air Temp. F
—10	220	111,800	119	82,000	99
0	200	97,000	112	71,000	93
10	190	90,000	108	65,500	91
30	160	69,500	97	51,300	84
50	130	51,000	87	38,000	78

Note 1. Water flow rate constant—based on 20F drop at 220F.
Note 2. Intermittent operation of unit heaters is permissible when outside temperatures are above 50F because stratification of air is no longer an important factor.

Maintenance costs are likewise often reduced to a new low. Insurance rates are said to be lower. Corrosion difficulties almost completely disappear due to lower temperatures and absence of possibly corrosive condensate. Expansion stresses are greatly reduced because of lower average temperatures and more gradual temperature variations. Repairs are simplified because of the feasability of arc welding water-filled lines under pressure, and the maintenance expense involved in the servicing of larger quantities of often inaccessible traps and pressure regulators is eliminated or greatly reduced.

Even more important than these many advantages, however, is the inherent ability of a hot water system to accomplish its primary objective: to efficiently and evenly deliver the correct amount of heat to counteract all heat loss and infiltration at the source and to be quickly reactive to simple manual or automatic control in adapting the flow of heat to rapidly changing requirements of building occupancy, ventilation loads, and outside temperature conditions.

The responsiveness of a unit heater to simple thermostatic control by means of stop-start motor operation is well known and quite widely utilized. The most successful hot water unit heater installations, however, combine this feature of unit heater operation with simple manual or automatic control to vary the water temperatures inversely with outside temperature fluctuations. This type of control permits almost constant unit heater operation thereby utilizing to the fullest

extent the ability of unit heaters to prevent the wasteful rise of heated air to ceiling areas; to blanket large doors, windows or other sources of excessive infiltration with a steady stream of heated air and to provide the ventilating effect of a constant, gentle circulation of room air.

The wide flexibility of such a system is graphically illustrated in the accompanying table which shows the capacity in Btu per hour and final air temperatures of a typical hot water unit heater when supplied with a constant water flow and a constant entering air temperature but with average water temperatures varied inversely with the outside temperature conditions.

For purposes of further indicating the superior relative performance of the hot water units, capacity data of a similar steam unit is also included in the chart.

An outstanding example of an installation utilizing all these advantages is a midwest manufacturer of small radio parts. The physical plant consists of a large saw-tooth factory building of conventional construction with concrete floors directly on the ground, large areas of leaky steel-sash windows and sky lights, and an uninsulated built-up roof. The working areas are largely occupied by rows of tables at which girls are seated, winding and glueing coils and other small parts. The poor construction of the building and the sedentary nature of the work plus the fact that temperatures throughout had to be evenly maintained at 70F to maintain the proper consistency of the glue, combined to make an unusually difficult set of conditions. A forced hot water system with hot water designed unit heaters was installed with a control system as previously described and the results were so completely satisfactory that the plant engineer has been known to assert that he would not consider any other type of system.

No discussion of any system can be complete without an acknowledgment of its disadvantages as well as its advantages.

In the event of a prolonged shut down there is always danger of freezing a hot water system unless it is carefully drained. The human element involved here can be easily and economically eliminated by providing solenoid operated drain valves at the low points in the system controlled by low temperature aquastats.

When water temperatures are controlled inversely with the outside temperature the unit heater outlet air temperature in the lower range of water temperatures may be so low as to have an uncomfortable cooling effect on persons working directly in the air stream. Unusual care must therefore be used to direct all unit heater air streams against walls or into unoccupied sections.

Hot water at the temperatures normally used is seldom adaptable for industrial processing, drying or cooking or for preheating outside ventilating air. Where such requirements exist it may be necessary or desirable to provide a separate small steam boiler plant for the process and ventilating loads or to provide the hot water required for heating from steam heated shell and tube converters. This method often has the advantage of economically using otherwise waste heat from after-coolers, engine jackets, process equipment or exhaust steam.

Determines Coal Ash Without Burning

A new kind of "seeing" instrument, or chemical detective, is the new General Electric X-ray Photometer which can make a rapid accurate analysis of the concentration of certain chemical elements in the presence of others. Plus its potential role as a detective in the exposure of spurious coins and fake diamonds, it can determine the ash content of any given sample of coal, sulphur content of oil tetraethyl content of gasoline or the heavy metal content of glass, plus concentration of fillers and impregnating agents in wood, cloth and rubber.

It operates by aiming an X-ray beam through material being tested and then measuring the amount of ray absorbed by the material. In estimating the amount of ray absorbed by the material. In estimating the amount of ash in a quantity of coal, the component chemicals that result in ash are checked for the amount of X-ray absorption and an aluminum disc which absorbs a like amount of radiation is selected. Then any sample of coal is matched against the disc. Since the amount of X-ray absorption of the sample is in ratio to its ash-producing elements, the amount of ash in the coal can be calculated.

In like manner oil can be checked for sulphur content and glass can be checked for lead content.

The X-ray Photometer measures ray absorption by directing an X-ray beam at a fluorescent screen. The strength of the ray after it has passed through material under test, is transposed by the screen into visible light, intensity of which is then measured by photoelectric equipment. Final reading is given on a dial. Thus a customer buying any quantity of coal, can through this combination of instruments find out whether he is getting the kind of coal for which his contract calls—an important matter where enormous quantities of fuel are purchased by a city, state or an institution for example. This comparatively simple test could be made in a few seconds before the coal is actually unloaded, from samples taken from the railroad car or truck.

Panel Heating; Open System Vs. Closed System

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HEATING AND VENTILATING'S
Reference Section

Panel Heating; Open System Vs. Closed System

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A theory and procedure in open warm air panel heating design is presented and compared to closed panel systems.

MOST panel heating systems operate with a closed cycle of the warming fluid. Hot water may be pumped in a closed system through pipe or tubing embedded in concrete floor panels or in plaster wall or ceiling panels. Also, air has been used as the warming fluid in closed ducts or airways. The open system, however, uses air as the heating fluid; after the air has warmed the panel (which may be placed in ceiling, wall, or floor), the air, cooled a few degrees in temperature by contact with the panel, may be introduced directly into the enclosure. By the use of cold air returns, as in forced warm-air heating, air at room temperature is then returned to the filtering equipment, heater, humidifier, and fan.

The closed system of panel heating provides heating, only. In this system, any control of room humidity, air cleaning, and air circulation is immediately lost. Some engineers might be interested in the performance characteristics of an open panel system, because in this system true air conditioning may still be obtained, and there is no sacrifice in the control of factors of physical environment, other than temperature, that may affect human comfort.

Open Panel

A theory of the design of open panel systems, similar in fundamental principles to the accepted theory of the design of closed panel heating systems is offered in this article. The theory is approximate in many instances and no more precise than the theory that has been presented for the design of closed systems, but the approximations are not so inexact as to handicap the application of the theory. Rather, they are necessary in order to simplify the theory to such an extent as to make it useful to engineers.

The following theory applies to the use of panels in any location.

Nomenclature

A_p = area of the heated panel, sq ft;
A_w = total area of unheated surfaces in the enclosure, sq ft;

$$M = \frac{A_p}{A_p + A_w}$$

$$N = \frac{A_w}{A_p + A_w} = 1 - M;$$

t_a = average temperature of indoor air, F;
t_p = average temperature of heated panel, F;
t_w = average temperature of unheated surfaces, F;
t_o = temperature of outdoor air, F;
t_1 = temperature of conditioned air entering panel, F;
t_2 = temperature of conditioned air leaving panel, F;
W_i = weight rate of infiltration and exfiltration, lb per hr;
W_c = weight rate of supply of conditioned air, lb per hr;
C_w = average thermal conductance of unheated room surfaces, Btu per hr sq ft F;

$$\frac{1}{\frac{1}{U_w} - 0.61}$$

(where U_w = average overall coefficient of heat transfer of unheated room surfaces, or $\frac{\Sigma A_w U_w}{\Sigma A_w}$);

h_w = average film coefficient of convective heat transfer from unheated room surfaces to room air, Btu per hr sq ft F;
h_p = average film coefficient of convective heat transfer from room side of heated panel to room air, Btu per hr sq ft F;
h_p' = average film coefficient of convective heat transfer from conditioned air to panel on plenum side, Btu per hr sq ft F.

Note: for floor warmer than air, $h = 0.38\ (\Delta t)^{0.25}$;
for vertical surfaces, $h = 0.27\ (\Delta t)^{0.25}$;
for ceiling warmer than air, $h = 0.20\ (\Delta t)^{0.25}$.

There are five basic design equations. The first equation gives the combination of air temperature and mean radiant temperature necessary to produce an operative temperature of 70F in still air. The mean radiant temperature is here expressed as the average temperature of the surfaces of the enclosure; the temperatures of the surfaces are weighted in proportion to their respective areas. The resulting "comfort" equation for residential heating is

$$t_a + 1.14\ M\ t_p + 1.14\ N\ t_w = 150 \qquad (1)$$

Where lower operative temperatures are desired, the value of the constant in Equation 1 may be reduced.

The second basic equation expresses the energy balance on the unheated surfaces of the enclosure. These surfaces are assumed to be receiving energy by radiation from the heated panel, losing heat by convection to the room air, and losing heat by conduction through the building structure. The short, approximate method of calculating radiant heat exchanges

introduced by F. W. Hutchinson is used here. In effect, this method divides the surfaces of the enclosure into heated panel and unheated surface. All of the radiant energy emitted by the panel is assumed to be absorbed by the unheated surfaces; the fraction of the radiant energy emitted by the unheated surfaces that is absorbed by the heated panel is $\frac{A_p}{A_w} = \frac{M}{N}$. It is further assumed that the rate of exchange of radiant energy is proportional to the difference between the temperatures of the surfaces with a factor of proportionality of 1.0 Btu per hr sq ft F. With these simplifying assumptions, the energy balance on the unheated surfaces of the enclosure becomes

$$\frac{M}{N}(t_w - t_p) + h_w (t_w - t_a) + C_w (t_w - t_o) = 0 \qquad (2a)$$

For all practical purposes, h_w may be assumed to be 0.5 Btu per hr sq ft F, or

$$\frac{M}{N}(t_w - t_t) + 0.5 (t_w - t_a) + C_w (t_w - t_o) = 0 \qquad (2b)$$

The third basic equation is the heat balance on the entire enclosure. Heat loss from the back face of the panel is ignored; conditioned air must then be supplied in amount and state to balance heat conducted through building structure and the heat required to warm in filtering air to room temperature. The heat balance is

$$0.24 W_c (t_1 - t_a) = C_w A_w (t_w - t_o) + 0.24 W_i (t_a - t_o) \qquad (3)$$

The fourth basic equation is an energy balance on the room side of the heated panel. The conditioned air supplied to the panel is cooled from t_1 to t_2 because of heat lost by convection from the heated panel to room air and because of exchange of radiant energy between heated panel and unheated room surfaces. The equation is

$$0.24 W_c (t_1 - t_2 = h_p A_p (t_p - t_a) + A_p (t_p - t_w) \qquad (4)$$

The fifth basic equation is a heat balance on the conditioned air flowing through the airway side of the panel. It is assumed that this air loses heat by convection to the one panel surface, only; the thermal resistance of the panel to the conduction of heat from the airway side to room side is ignored, and the temperature of the panel surface is assumed to be uniform. Then,

$$0.24 W_c (t_1 - t_2) = \frac{h_p' A_p (t_1 - t_2)}{\ln \left(\frac{t_1 - t_p}{t_2 - t_p} \right)},$$

or

$$\ln \left(\frac{t_1 - t_p}{t_2 - t_p} \right) = \frac{h_p' A_p}{0.24 W_c},$$

or

$$\frac{t_1 - t_p}{t_2 - t_p} = e^{\frac{h_p' A_p}{0.24 W_c}} \qquad (5)$$

It will be noted that there are sixteen variables appearing in these five equations. In the usual design procedure, the design temperature of the outdoor air, t_o, will be fixed. A study of the building construction will establish the panel arrangement that is to be used. After a panel size and location is tentatively fixed, values for M, N, A_p, and A_w may be found. Values for C_w and W_i may be estimated as in conventional methods of determining building heat losses. The value of h_p will depend upon panel location and upon the difference between temperatures of heated panel and room air (see earlier equations). As stated before, a value of 0.5 Btu per hr sq ft F may generally be used for h_w.

The value of h_p' will depend upon the velocity of the supply air as it traverses the airway side of the panel in flowing to the panel outlets; depending upon this velocity, values of h_p' will generally fall between 1 and 3 Btu per hr sq ft F. Examination of the problem of satisfactory distribution of the air from the panel outlets would generally result in an assignment of a reasonable value to rate of supply of conditioned air to the panel of the first (or control) room; W_c is then fixed. (The distribution of air is discussed in a later section.) With this procedure, five variables remain (all temperatures), t_a, t_p, t_w, t_1, and t_2. Since there are five basic design equations, these equations may be solved for the five temperatures.

Most engineers would not use this design procedure if it were not developed further. To simplify the solution, a tabular calculation is introduced at this point. There is no need of retaining h_w as a variable; instead a reasonable value of 0.5 has been assigned to h_w in preparing the table.

It is convenient to assign new symbols to certain combinations of the original variables as follows:

Let

$$X = \frac{0.24 W_c}{A_w};$$

$$Y = \frac{0.24 W_i}{A_w};$$

then

$$\frac{0.24 W_c}{A_p} = \frac{XN}{M};$$

let

$$Z = e^{\frac{h_p' A_p}{0.24 W_c}}$$

The rate of heat loss from the room may be found after the five basic equations are solved as

$$q = 0.24 W_c (t_1 - t_a) \qquad (6)$$

An example of the solution will be given, and a standard form of solution that has been used by the author is given. The room of the example is 14 ft by 20 ft with a ceiling height of 8 ft 6 in. The room is a corner room with two exterior walls ($U = 0.15$); there are two single-glass double-hung wood sash windows in one wall and one in the shorter exterior wall ($U = 1.13$); each window is 3 ft by 5 ft. No heat

loss occurs through ceiling, floor, or interior partitions. Heated panels over a portion of the ceiling near the exterior walls will be used; the total area of such ceiling panels will be 120 sq ft. The design temperature of the outdoor air will be taken as —10F. The film coefficient of convective heat transfer on the room side of the heated panel will be assumed to be $h_p = 0.4$ Btu per hr sq ft F; the film coefficient of convective heat transfer on the airway side of the heated panel will be assumed to be $h_p' = 2.00$ Btu per hr sq ft F. Consideration of the air distribution has led to fixing the rate of supply of conditioned air to the panel as 600 lb per hr. The standard form of solution follows (refer to Table 1).

will leave the panel at about 103F; the thermal environment at the design conditions is made up of an air temperature of 72F and a mean radiant temperature of 68.5F. The calculated rate of heat loss from this room is 9160 Btu per hr. By increasing the rate of supply of conditioned air to this room, the temperature at which this air would have to be supplied would, of course, be reduced.

After the temperature of the conditioned air supplied to one room of the structure is established, the temperature of the air supplied to all other rooms will be the same unless there is zoning or unequal losses of heat in the supply ducts. The design problem then is to find the rate of supply of conditioned air to each

Table 1 — Tabular Solution of Equations 1, 2b, 3, 4, and 5

(Fixed variables are A_p, A_w, M, N, t_o, W_1, W_c, C_w, h_w, h_p, and h_p')

Equation	Column Headings in Estimate Sheet, Open Panel					
	a	b	c	d	e	f
	Coefficients of					Constant
	t_a	t_p	t_w	t_1	t_2	
1	1	$1.14M$	$1.14N$	0	0	150
2	—1	$-\frac{2M}{N}$	$\frac{2M}{N} + 2C_w + 1$	0	0	$2C_w t_o$
3	$X + Y$	0	C_w	$-X$	0	$(C_w + Y) t_i$
4	$-h_p$	$1 + h_p$	—1	$-\frac{XN}{M}$	$\frac{XN}{M}$	0
5	0	$Z - 1$	0	1	$-Z$	0
6	0	$b_1 + b_2$	$c_1 + c_2$	0	0	$f_1 + f_2$
7	$-\frac{a_4}{e_4}$	$-\left(\frac{b_4}{e_4} - \frac{b_5}{e_5}\right)$	$\frac{1}{e_4}$	$1 + \frac{1}{e_5}$	0	0
8	$a_7 - \frac{a_3 d_7}{d_3}$		$c_7 - \frac{c_3 d_7}{d_3}$	0	0	$-\frac{f_3 d_7}{d_3}$
9		$a_8 b_2$	$a_8 c_2$	0	0	$a_8 f_2$
10	0	$b_7 + b_9$	$c_8 + c_9$	0	0	$f_8 + f_9$
11	0	$b_6 \frac{c_{10}}{c_6}$		0	0	$f_6 \frac{c_{10}}{c_6}$
12	0	$b_{10} - b_{11}$	0	0	0	$f_{10} - f_{11}$

Solution: $t_a = \frac{f_{12}}{b_{12}}$; $t_1 = \frac{f_3 - a_3 t_a - c_3 t_w}{d_3}$;

$t_w = \frac{f_{10} - b_{10} t_p}{c_{10}}$; $t_2 = \frac{-b_5}{e_5} t_p - \frac{1}{e_5} t_1$.

$t_a = f_1 - b_1 t_p - c_1 t_w$;

The performance of the open panel predicted from the results for the example show that the room must be supplied with conditioned air at the rate of 600 lb per hr and at a temperature of 136F to maintain an operative temperature of 70F when 43% of the ceiling is used as a heated panel of the open type. The air

of the other rooms. Unfortunately, however, solution of the five basic design equations given here is difficult when t_a, t_p, t_w, t_2, and W_c are to be found when the other eleven variables are assigned values. Instead, it is easier to assume a value for W_c and solve the equation as before for t_a, t_p, t_w, t_1, and t_2. If the first

Estimate Sheet; Open Panel

Room No. F1 Drawing No. Design outdoor temp. —10F

Panel location: Ceiling Panel area: 120 sq ft Room dim., ft: 14 × 20 × 8½

Area of unheated surfaces: 1018 sq ft Windows: (3) 3 ft × 5 ft D.H.W.S.

Crack for infilt. 38 ft

$$U_w = \frac{45\,(1.13) + 244\,(0.15)}{1018} = 0.086$$

$$C_w = \frac{1}{\frac{1}{0.086} - 0.61} = 0.0905$$

$W_i = 38\,(39)\,(0.075) = 111$ lb per hr

$W_c = 600$ lb per hr

$$M = \frac{120}{1138} = 0.105 \qquad N = 0.895$$

$h_p = 0.4$; $h_p = 2.0$

$$X = \frac{0.24\,(600)}{1018} = 0.142; \qquad Y = \frac{0.24\,(111)}{1018} = 0.026; \qquad Z = e^{\frac{0.24\,(600)}{2\,(120)}} = 5.3$$

Equation	a	b	c	d	e	f
1	1	0.12	1.02	0	0	150
2	—1	—0.236	1.417	0	0	—1.81
3	0.168	0	0.0905	—0.142	0	—1.16
4	—0.4	1.4	—1	—1.20	1.20	0
5	0	4.3	0	1	—5.3	0
6	0	—0.116	2.437	0	0	148.2
7	0.333	—1.978	0.833	0.811	0	0
8	1.293		1.349	0	0	—6.62
9		—0.305	1.83	0	0	—2.34
10	0	—2.283	3.179	0	0	—8.96
11	0	—0.152		0	0	193.5
12	0	—2.131				—202.46

$$t_p = \frac{-202.5}{-2.131} = 95\text{F}$$

$$t_w = \frac{-8.96 + 216.89}{3.179} = 65.3\text{F}$$

$$t_1 = \frac{-1.16 - 12.1 - 5.91}{-0.142}$$

$= 135.6$F

$t_a = 150 - 11.4 - 66.6 = 72.0$F

Rate of heat loss $= 0.24\,(600)\,(135.6 - 72.0)$
$= 9160$ Btu per hr

$t_2 = 77 + 25.6 = 102.6$F

value of t_1 found is not the value already established for the temperature of the conditioned air to be supplied to all rooms find a new value for W_c as follows:

$$(W_c)_2 = (W_c)_1 \frac{[(t_1)_1 - 70]}{[(t_1)_2 - 70]}$$

where

$(W_c)_1$ = first trial value of W_c;

$(t_1)_1$ = value of t_1 found from first solution of five basic equations;

$(t_1)_2$ = value of t_1 to be used for conditioned air supplied to all rooms.

Closed Panel; Thermal Environment

The theory of design of the closed panel has been presented by other writers, but for purposes of comparison with the open panel system, a similar design procedure for the closed panel is given here with a form of estimate sheet that has been devised and used by the writer. The first two basic equations are the same as for the open panel design:

the "comfort" equation for residential heating is

$$t_a + 1.14\,M\,t_p + 1.14\,N\,t_w = 150 \qquad (7);$$

the energy balance on the unheated surfaces of the room is

$$\frac{M}{N}(t_w - t_p) + 0.5\,(t_w - t_a) + C_w\,(t_w - t_o) = 0 \qquad (8)$$

The third basic equation is the heat balance on the infiltering and exfiltering air, or

$$0.24\,W_i\,(t_a - t_o) = h_p\,A_p\,(t_p - t_a) + 0.5\,A_w\,(t_w - t_a) \qquad (9)$$

As before, let $Y = \dfrac{0.24\,W_i}{A_w}$; then Table 2 gives a tabular solution of the three basic equations for closed panel heating.

As an example of the application of this theory of design of closed panel heating, assume that the room of the previous example is to be heated with a closed panel using the entire floor. The same design outdoor temperature will be used, and the new heating system will be designed to produce an operative temperature of 70F. The convective film coefficient of heat transfer for the floor panel will be assumed to be 0.8. A form of estimate sheet that uses the tabular method of solution given in Table 2 follows:

Table 2 — Tabular Solution of Equations 7, 8, and 9

(Fixed variables are A_p, A_w, M, N, t_o, W_i, C_w, h_w, and h_p)

Equation	Column Headings in Estimate Sheet, Closed Panel			
	a	b	c	f
	Coefficients of			
	t_a	t_p	t_w	Constant
1	1	1.14M	1.14N	150
2	−1	$-\frac{2M}{N}$	$\frac{2M}{N} + 2C_w + 1$	$2\,C_w\,t_o$
3	$Y + \frac{h_p M}{N} + 0.5$	$-h_p\frac{M}{N}$	−0.5	$Y\,t_o$
4	0	$b_1 + b_2$	$c_1 + c_2$	$f_1 + f_2$
5	$-a_3$	$a_3\,b_2$	$a_3\,c_2$	$a_3\,f_2$
6	0	$b_3 + b_5$	$c_3 + c_5$	$f_3 + f_5$
7	0	$b_4\frac{c_6}{c_4}$	c_6	$f_4\frac{c_6}{c_4}$
8	0	$b_6 - b_7$	0	$f_6 - f_7$

$$t_p = \frac{f_8}{b_8}$$

$$t_w = \frac{f_4 - b_4\,t_p}{c_4}$$

$$t_a = f_7 - b_7\,t_p - c_7\,t_w$$

Heat loss, $q = C_w\,A_w\,(t_w - t_o) + 0.24\,W_i\,(t_a - t_o)$

Use of the entire floor as a heated panel requires a floor surface temperature of about 86F; the operative temperature of 70F is realized in this closed panel system with an air temperature of 69.4F and a mean radiant temperature of 70.6F. The rate of heat loss from the enclosure is 9200 Btu per hr.

Warm Air Heating

The conventional method of designing a warm-air heating system pays no regard to mean radiant temperature. Actually, however, the air temperature should be higher, with any system of heating, when the mean radiant temperature is low, and mean radiant temperature is just as significant in the design of warm-air heating as it is in the design of panel heating. There are three basic equations that apply to the design of warm-air heating where there is no heated panel in the enclosure, but where the conditioned air is supplied at a temperature higher than the temperature of the room air.

The same comfort equation applies with any method of heating, and is, again, based upon maintaining an operative temperature of 70F for residential heating.

$$t_a + 1.14\,t_w = 150 \qquad (10)$$

The heat balance on the room surfaces is written on the assumption that the average value of the film coefficient of convective heat transfer of the room surfaces is 0.5; then, heat transferred by convection from room air to room surfaces must balance the heat conducted through the building structure to the outdoor air, or

$$0.5\,(t_a - t_w) = C_w\,(t_w - t_o) \qquad (11)$$

The conditioned air must be supplied in such a state and at such a rate as to balance the total rate of heat loss due to conduction and infiltration, or

$$0.24\,W_c\,(t_1 - t_a) = C_w\,A_w\,(t_w - t_o) + 0.24\,W_i\,(t_a - t_o) \qquad (12)$$

Solution of the three basic equations gives:

$$t_w = \frac{75 + C_w\,t_o}{1.07 + C_w};$$

$$t_a + 150 - 1.14\,t_w;$$

$$W_c = \frac{4.17\,C_w\,A_w\,(t_w - t_o) + W_i\,(t_a - t_o)}{t_1 - t_a}.$$

The rate of heat loss from the enclosure is

$$q = 0.24\,W_c\,(t_1 - t_a)$$

The results of applying these equations to the same room used before as the example for open and closed panel heating analysis follow:

$$U_w = \frac{45\,(1.13) + 244\,(0.15)}{1138} = 0.0768,$$

and

$$C_w = \frac{1}{\frac{1}{0.0768} - 0.61} = 0.0807;$$

Estimate Sheet; Closed Panel

Room No. F1 Drawing No. Design outdoor temp. —10F

Panel location: Floor Panel Area: 280 sq ft Room dim., ft: 14 × 20 × 8½

Area of unheated surfaces: 858 sq ft Windows: (3) 3 ft × 5 ft D.H.W.S.

$$U_w = \frac{45\ (1.13) + 244\ (0.15)}{858} = 0.102$$

Crack for infilt. 38 ft

$$C_w = \frac{1}{\frac{1}{0.102} - 0.61} = 0.109$$

$W_i = 38\ (39)\ (0.075) = 111$ lb per hr

$h_p = 0.8$

$$M = \frac{280}{1138} = 0.246 \qquad N = 0.754 \qquad Y = \frac{0.24\ (111)}{858} = 0.311$$

Equation	a	b	c	f
1	1	0.28	0.86	150
2	—1	—0.654	1.872	—2.18
3	0.793	—0.262	—0.5	—0.31
4	0	—0.374	2.732	147.8
5	—0.793	—0.518	1.487	—1.73
6	0	—0.780	0.987	—2.04
7	0	—0.135	0.987	53.3
8	0	—0.645	0	—55.34

$$t_p = \frac{-55.34}{-0.645} = 85.7\text{F} \qquad t_w = \frac{147.8 + 32.1}{2.732} = 65.8\text{F} \qquad t_a = 150 - 24.0 - 56.6 = 69.4\text{F}$$

Heat loss, $q = 0.109\ (858)\ (75.8) + 0.24\ (111)\ (79.4) = 9200$ Btu per hr

$$t_w = \frac{75 - 0.8}{1.15} = 64.6\text{F};$$

$$t_a = 150 - 73.6 = 76.4\text{F}.$$

If it be assumed that the temperature of the conditioned air supplied to the room is 140F, the rate of supply of conditioned air is

$$W_c = \frac{4.17\ (0.0807)\ (1138)\ (74.6) + 111\ (86.4)}{63.6} = 600$$

lb per hr.

The rate of heat loss from the room is

$$q = 0.24\ (600)\ (63.6) = 9160 \text{ Btu per hr}$$

When the same design procedure is applied to heating the one room of the example by an open panel system, a closed panel system, and a warm-air system, results condensed in Table 3 are obtained. There is no significant difference in the rate of heat loss from

Table 3 — Comparison of Heating Methods

(room of example has 244 sq ft of exterior wall with U = 0.15, 3 windows, each 3 ft by 5 ft with U = 1.13, and infiltration is at the rate of 111 lb per hr; design temperature of outdoor air is —10F; operative temperature in each case is 70F).

Heating System	Heated Panel,	Temp. of Heated Panel F	Temp. of Room Air, F	Room Mean Radiant Temp. F
Open panel	43% of ceiling	95.0	72.0	68.5
Closed panel	Entire floor	85.7	69.4	70.6
Warm air	None	...	76.4	64.6

the room between any of the three methods when the same thermal environment, as measured by operative temperature, is created.

Air Distribution with Open Panel

If a ceiling panel be used in an open panel system of heating, the conditioned air supplied to the panel may be blown vertically down into the room either through a large number of small holes (perforated panel) or through long, narrow slots (slotted panel). The velocity at the outlet and the size and shape of the outlet must be chosen so that the residual velocity of the air stream is not large enough to create unpleasant air movement in the occupied zone.

Tuve and Priester have investigated the application of the theory of conservation of momentum to the estimate of terminal velocity of blow from outlets of various shapes and sizes. Unfortunately, however, the experimental work does not cover the low outlet velocity range contemplated for the open panel. There are a few facts, however, which permit the presentation of an incomplete theory.

The primary air leaving the outlet entrains room air into the stream, and the average velocity of the combined stream decreases as the distance from the outlet increases. The velocity over the entire section of the air stream is not uniform; the maximum velocity at the core of the stream may be about 2.5 times the average velocity. The core of the stream finally disappears and the entire cross section is a mixing region. From tests of Tuve, Priester, and Wright, it appears as if the momentum of the total air stream decreases slightly near the outlet but remains nearly constant throughout the blow. The boundary of the air stream inclines to the axis of blow with a total included angle of between 19° and 25°. If the density of the primary air is less than that of the room air, there is a buoyant effect upon the air stream tending to decrease the residual vertical velocity for downward blows.

Experimental results now available will not permit a precise equation, but the following approximate results may be used:

Let

V_o = average velocity of primary air at outlet, ft per min, $= \dfrac{Q_o}{A_o}$,

where

A_o = free area of outlet, sq ft;

Q_o = volume rate of flow of primary air at outlet, cfm;

V = average residual velocity of air stream at any section, fpm;

A = area of cross section of air stream at any section, sq ft.

Assume the momentum of the total air stream after mixing occurs is about 81% of the momentum of the stream of primary air at the outlet as calculated from the average velocity of the primary air at the outlet $\left(\dfrac{Q_o}{A_o}\right)$, and ignore the difference in the density of primary air and room air. Then

$$0.81\ A_o\ V_o^2 = A\ V^2$$

or

$$V = \frac{0.9\ Q_o}{A_o}\sqrt{\frac{A_o}{A}} \qquad (13)$$

Assume, first, a round outlet with a radius of r_o ft. Assume, also, that the total angle included by the air stream is 23° (tan 11.5° = 0.2).

After a blow of L ft downward,

$$\sqrt{\frac{A_o}{A}} = \frac{1}{1 + \dfrac{0.2\ L}{r_o}},$$

and

$$V = \frac{0.286\ Q_o}{r_o^2 + 0.2 L\ r_o},$$

from which

$$r_o = 0.5\sqrt{0.04\ L^2 + 1.14\frac{Q_o}{V}} - 0.1\ L \qquad (14)$$

Assume that it is required that the average residual velocity not exceed 50 fpm at a distance of 1 ft below the ceiling panel. Then,

$$r_o = 0.5\sqrt{0.04 + 0.023\ Q_o} - 0.1 \qquad (15)$$

For slotted outlets with length of a_o ft and width of b_o ft, assume an equivalent radius such that

$$r_o = \sqrt{\frac{a_o\ b_o}{\pi}} \qquad (16)$$

If these equations be applied to the open panel used for the room of the previous examples (14 ft × 20 ft × 8½ ft with 120 sq ft of ceiling panel), for the required rate of supply of primary air of 143 cfm,

$$r_o = 0.5\sqrt{3.33} - 0.1 = 0.81 \text{ ft}$$

Multiple orifices apparently produce an air stream that behaves almost like the stream from a single outlet of the same total area. Therefore, if a *perforated* ceiling panel having holes each 5/64 in. in diameter were to be used, the number of holes in a square foot of panel would need to be about

$$n = \frac{4\ (9.72)^2}{120\left(\dfrac{5}{64}\right)^2} = 520$$

If slotted panels were used with a ¼-in. width of slot, the required total length of slot would be about

$$a_o = \frac{\pi\ r_o^2}{b_o} = \pi\ (0.81)^2\ (48) = 99 \text{ ft}$$

If parallel, narrow slots are used in one panel, the slots should be at least 8 in. apart in order to prevent interference with the induction of room air into each stream.

Ventilation of Long Tunnels During Construction

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Concluding section of a three-part article discusses dust control and the ventilation of open ends.

THE use of large quantities of air for ventilating underground areas poses a problem of temperature control which is important from two standpoints—health protection and safety as affected by the reduction of visibility caused by fog. Where the distance from the outside to the operating face is relatively short, any air which is blown directly to that face will reflect outside air conditions. This means excessive moisture for a large portion of the summer. For the New York State area it can be predicted that saturated air would be delivered from the pipe continuously from June 1 to mid-September if the underground (rock) temperature is of the order of 56F.

On the other hand, during the winter months, the governing factor would be chilling of personnel. It can be predicted that from November 1 to April 1, the temperature of the emergent air would be such as to cause excessive drafts, at least 10F below underground temperature.

It was found, however, in the operations under consideration, that when the length of pipe run exceeded 2,000 ft, the temperature and humidity attained a static condition, which was negligibly affected by outside air conditions. Air which was discharged into the working area from the main air supply under these conditions was within one or two-tenths of a degree of the rock temperature, and within a few percent of saturation. Velocity of this air at the time of reaching the working zone was low compared to that stirred up by the drills during drilling, so that normal working clothing was adequate temperature protection. This means that an operation which has progressed sufficiently far to have 2,000 ft of vent pipe in an underground area will require no special measures to protect against outside temperature as introduced by pressure ventilation.

At the same time, the expansion of the discharged air under these conditions is sufficient to lower its humidity enough to disperse most fog in the area into which it is blown. If it is essential to exhaust throughout the drilling cycle, or during any other operation where large quantities of compressed air are used, it can be expected that fairly dense fogging will result unless special measures are taken to prevent it. These measures include slight localized heating of the tunnel air, and recirculating large quantities of air in the fogging area. Equipment has been designed which will heat the compressed air sufficiently to eliminate fogging from this source, but no opportunity was had to check the effect of this heater. At any rate, it was found necessary to operate under continuous exhaust

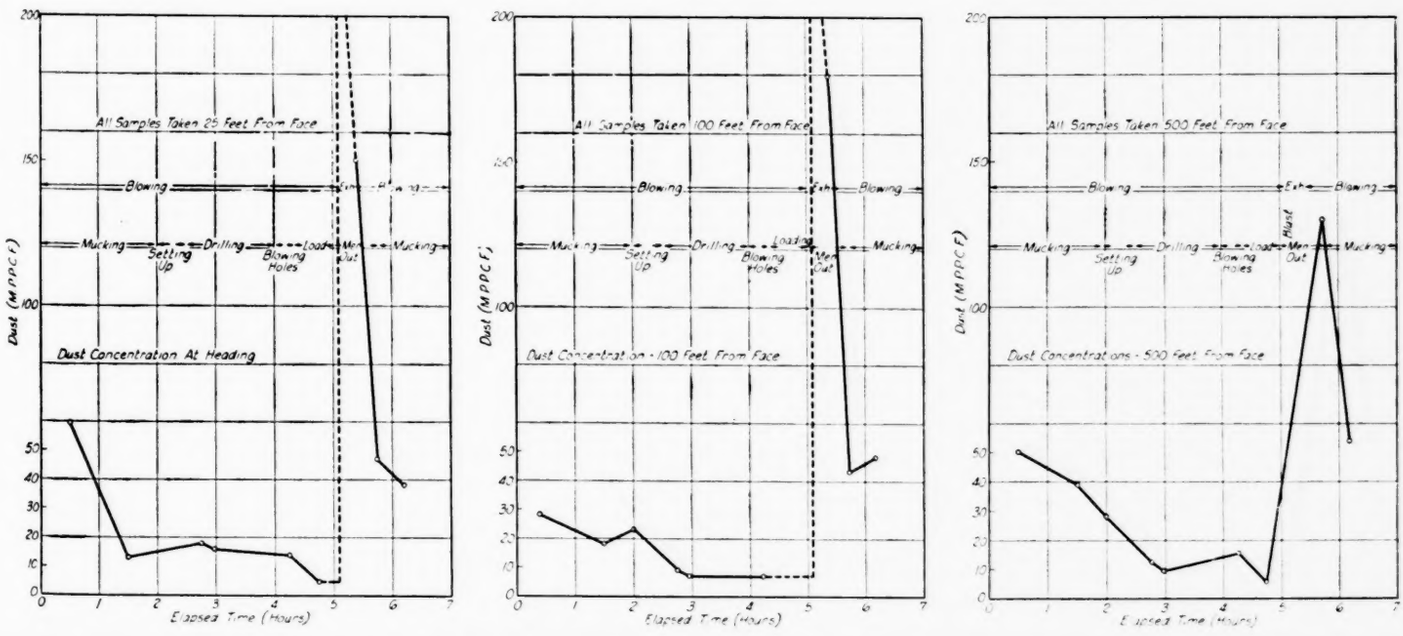

Fig. 9. Dust concentration in a very dry tunnel. From left to right, graphs show dust concentration at the heading, 100 ft from the face and 500 ft from the face.

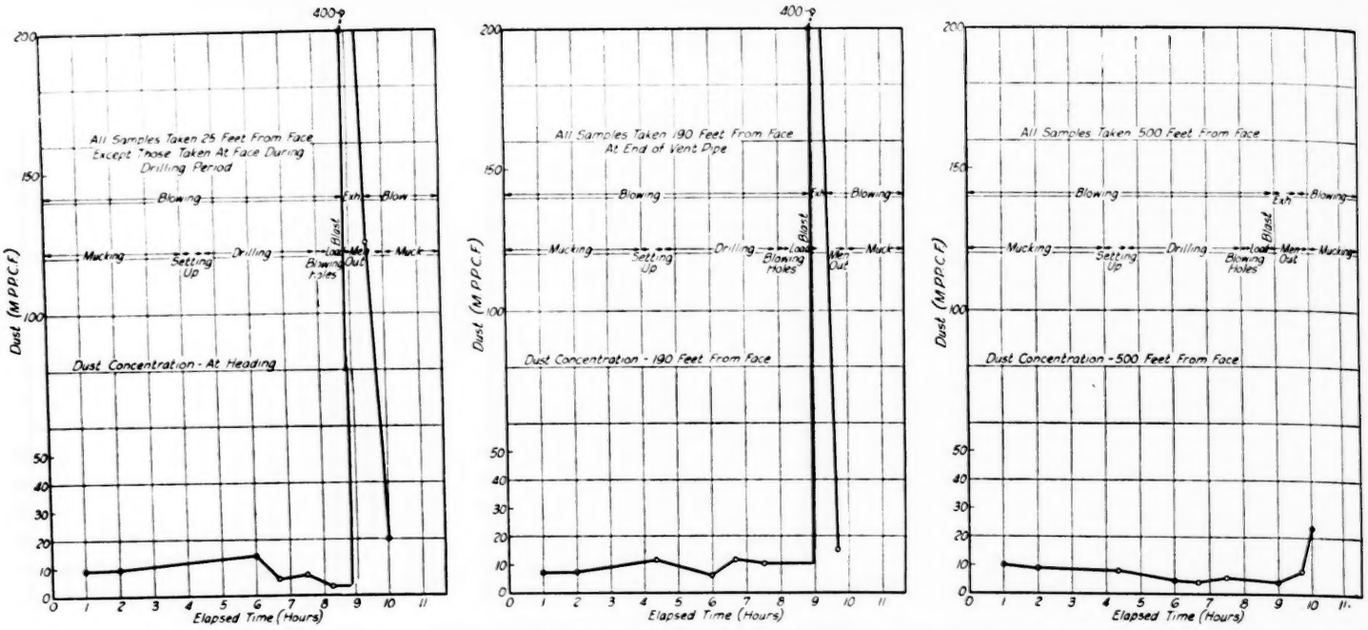
All Samples Taken 25 Feet From Face Except Those Taken At Face During Drilling Period
Dust Concentration - At Heading
All Samples Taken 190 Feet From Face At End of Vent Pipe
Dust Concentration - 190 Feet From Face
All Samples Taken 500 Feet From Face
Dust Concentration - 500 Feet From Face
Dust (MPPCF)
Elapsed Time (Hours)
Blowing
Mucking
Setting Up
Drilling
Muck
Exh.
Blast

Fig. 10. Dust concentrations in a very wet tunnel. Left to right, dust concentration at the heading, 190 ft from the face and 500 ft from the face.

only in those operations which were carried on in potentially gassy areas.

Control of Dust

Previously, it was stated that ventilation at the rate prescribed by the New York State Code was sufficient to control most dust conditions. In another report, results of analyses of many hundreds of dust samples are summarized and show typical dust concentrations during all operations. To show sources of dust production and the controlling effect of ventilation at various working points, curves have been plotted of dust concentrations taken throughout complete operating cycles. Figs. 9 and 10 show two sets of such curves. Each is fairly representative of the conditions for which it is plotted. The three curves of each set are for samples taken simultaneously at three locations as related to the tunnel face: end of vent pipe, 25 ft back, and 500 ft back. It should be noted that dust production during blasting and mucking is considerably higher when operations are in dry rock than in wet rock, and also that reduction of concentration is much slower under dry conditions. This can largely be overcome by the continuous use of large quantities of water, including the use of the spray nozzle described previously.

Methane

Although the experience of the author with methane gas in underground operations is meager as compared with that of persons working in normally gassy regions, we did have continuous seepage of gas into one of our locations, and occasional bursts of fairly large quantities of explosive gas. To reduce pocking of gas in the tunnel, only exhaust ventilation was allowed. When a gas bleeder was found between the open air and the entrance to the exhaust pipe, this location was checked frequently and regularly by an experienced fireboss for concentration buildup.

Also it was necessary to maintain a continuous exhaust directly from the face throughout the drilling period. This was accomplished by mounting an exhaust fan on the drill carriage connected by ductwork to the front edge of this carriage. This fan discharge was led back into the exhaust pipe by means of a flexible tube. This arrangement was effective in clearing the air adequately, with a minimum of work stoppage, during the few occasions that gas pockets were encountered during drilling. Of course the quantity of air used merely governs the length of time that men must be withdrawn in case of a sudden inrush of gas.

Regulations followed in New York State prohibited return of the workers until the concentration was below 0.5% methane. On at least one occasion this requirement was not met for very nearly 24 hours after the sudden outburst of a pocket. It would be recommended on the basis of our experience that for

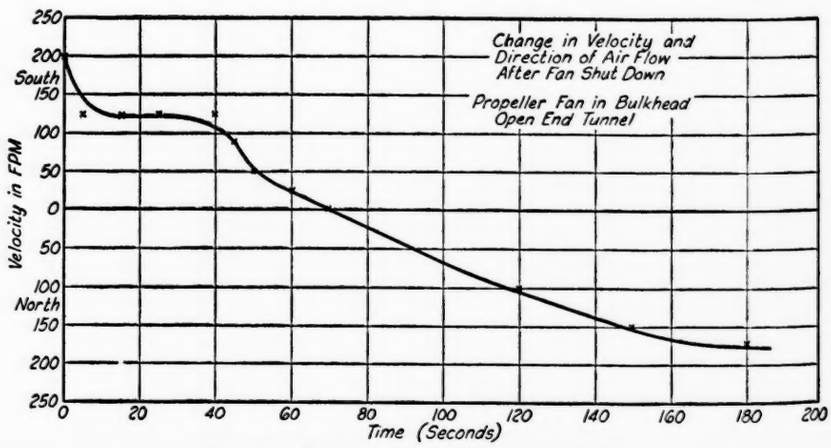
Change in Velocity and Direction of Air Flow After Fan Shut Down
Propeller Fan in Bulkhead Open End Tunnel
South
North
Velocity in FPM
Time (Seconds)

Fig. 11. Flow of air with fan shut off.

gassy areas, a very stringent maintenance program be kept so that the design air quantity be available at all times at the operating face. Also, a standby fan should be kept available to allow an immediate increase in the ventilation rate as required. This fan could be kept available for two headings, in the case of two-way operations from a shaft.

Ventilating Open Ends

With the holing through of two approaching bores, underground operations do not cease, nor do the problems of ventilation. The method of ventilating the tunnel area does change, because of several factors. Not the least of these factors is the necessity of removing the pipe carrying the ventilating air in order that cleanup and concreting operations may go forward.

Natural ventilation is a seemingly obvious choice for open tunnels. However, it is effective only where a strong chimney effect is present — an effect that depends on elevation and condition of surrounding terrain. The direction of flow is usually very uncertain and on most days will change. When dusty operations, as gunniting, are being carried on, they may be done when the air is blowing away from the main body of workers but not when it is reversed. Also, it was found impossible to predict direction of flow before holing through. This may be important for work layout. As a result of all of these considerations, reliance on natural draft for an air supply underground, when ventilation is required, is definitely not recommended.

An efficient, relatively inexpensive method of ventilation was evolved in one of the tunnels requiring ventilation because diesel engines were to be used during the pouring of a concrete lining. A wooden bulkhead was installed in the tunnel which completely closed it. Bulkhead location was not important. A door was placed in the bulkhead to allow passage of transportation equipment. Above this door was installed a 60 in. diameter adjustable pitch propeller fan rated to deliver 20,000 cfm against ½ in. S.P. The 20 hp motor driving this fan was reversible and could drive the air in either direction, depending on the site of production of hazardous materials, or on the direction of natural flow if no special hazard was to be controlled. Fig. 11 shows the rate of change of air flow as this fan was shut off. In this case it was necessary to move the air from north to south because of a gunniting operation being carried on to the south of the concrete placing.

Because of the excessive dust quantities created by gunniting, it would have been impossible to carry on both operations simultaneously with the natural flow which was from south to north. Pressure across the bulkhead with the door closed and fan shut off was 0.4 in. It was found that it was necessary to station a man permanently at this bulkhead to open and close the access door during all working hours.

Summary

Fundamental data on the design of ventilation systems, including proper type of equipment for underground operations is presented based on a 2-year study of tunneling operations on the Delaware Aqueduct. Operations are divided into those carried on in dead end and in open end tunnels. Various methods of ventilation including the use of many types of auxiliary equipment are discussed, showing the effect of each in controlling fog, dust, gases and temperatures. Equipment discussed includes fans, piping, method of pipe coupling and boosters. Variables encountered in predicting size and power of equipment are listed and the factors of piping resistance and leakage are discussed at length. Curves showing these factors are presented. These curves are based on experience with piping up to 20,000 ft in length and 28 in. in diameter.

Propane by Ship

Shown left are two of the many huge tanks being installed aboard a specialized tanker by the Warren Petroleum Co. for the first large-scale transportation of propane fuel by ship. The vessel will bring the liquid equivalent of 400,000,000 cu ft of propane gas to New York each month to help relieve the fuel shortage. When the big tanks are emptied of liquid propane they will still be filled with 266,000 pounds of propane gas, and special centrifugal equipment supplied by Carrier Corp., will condense it into liquid to prevent this fuel from making a return trip to the Texas fields.

Avoid Patent Law Suits

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Here are some important facts regarding infringement on patents and protection that is provided by patent law. Heating contractors and engineers will find interesting cases reviewed to emphasize court rulings.

RECENTLY several heating contractors have been sued by patentees for infringement of patents. The reason so many heating contractors become involved in litigation with patentees is because few readers know patent law. Therefore, we shall review important phases of the patent law, as based upon leading higher court cases, so that readers may know when infringement exists.

First, it is important to know that patents are subdivided into six classes: machine, article of manufacture, composition of matter, chemical process, mechanical process, and design. Machine patents relate to any operative device. Article of manufacture patents may be obtained on useful devices which are not necessarily operative machines. Composition of Matter patents are for mixtures of ingredients. Chemical and Mechanical Process patents relate to new methods of accomplishing a new or old result chemically or mechanically, respectively. Design patents relate only to ornamental and artistic things.

Infringement Law

The law is well established that any heating contractor who makes, sells, or uses a patented invention, without authority of the patentee, is liable for infringement. Moreover, it is immaterial whether the heating contractor who uses the patented invention is aware that he is an infringer. In other words, an innocent infringer is equally as liable as an intentional one.

Modern higher courts consistently hold that a patent gives the patentee the exclusive right to *make, sell and use* the invention during the term of the patent. He may refuse to make and sell the invention, or license others to benefit by its use, if he so desires. (47 U. S. 146).

In a recent case an architect had specified certain patented heating equipment. The contractor immediately communicated with the patenteee in view of obtaining a license to use the invention. The inventor refused to issue a license without stating his reasons for the refusal. The contractor proceeded to make and install the patented equipment without a license. The contractor was liable as an infringer.

And, in the leading case of Jackson v. Nagle, 47 F. 703, it was disclosed that a principal contractor awarded a contract to a subcontractor. A patentee sued both the principal contractor and the subcontractor for infringement of his patent because the subcontractor used certain appliances which infringed the patent.

The court held both the principal contractor and the subcontractor liable for infringement, and explained the law as follows:

"A contractor who makes an agreement to perform certain work, necessarily assumes the risk of infringing upon the exclusive patent rights of others, and if he does so infringe, he cannot avoid responsibility because he was doing the work for other persons. If a contractor violates the patent rights of another, he is, of course, answerable for the infringement. *A subcontractor stands upon the same footing.*"

Personal Use of Patented Article

Still another common source of litigation is where a person makes a patented article for his own use. It is important to know that the law is well settled that a person may not without liability for infringement make a patented article for his own individual use.

Of course, if patent claims are "weak," a slight modification of the invention will avoid infringement. On the other hand, if the patent contains basic claims, the inventor may prevent all other persons from making, selling or using a product *even remotely similar.*

To illustrate the far reaching effects of the patent infringement laws, we shall review a quite recently decided case. Here it was disclosed that several persons living in different states each arranged to make a separate part of an invention. These various parts were shipped to a person who lived in a different state and the latter assembled the parts into an infringing device. The patentee learned of the infringment and immediately filed suit against all of the parties involved in the conspiracy to infringe his patent. It is interesting to observe that the court held all of the involved persons liable to the patentee for damages and the full profits realized from sale of the infringing device.

In still another case (80 F. 712) a person was held liable as an infringer where it was shown that he used only one part of a patented article. In still another instance (229 F. 429) it was proved that a seller sold a single part of a patented article to a contractor and explained to the latter how the part could be assembled with other parts into an infringing device. In cases of this nature the seller of the part and also the contractor were held liable as infringers.

Therefore, it is quite apparent that all persons are liable for infringement who perform acts which tend to induce infringement.

In the recent case of General v. Sutter, 186 F. 637, a higher United States court defined the term "contributory infringement" in the following language:

"The legal principles governing contributory infringement exists where one *knowingly* concerts or acts with another in an unlawful invasion of a patentee's rights."

Infringement Damages

The measure of damages that a heating contractor must pay for infringement is *not* the *profits* which the patentee lost by reason of the infringement. The amount of the damages recoverable by the patentee depends upon his ability to prove losses. The courts may allow three times this amount. Also, it is important to know that *additional* heavy damages may be allowed by the courts where it is shown that the infringement was "willful and intentional." Thus where the contractor continues the infringing acts after having full knowledge of the patent, extra heavy damages may be allowed. Under these circumstances the patentee may recover a judgment against the infringer for the profits earned, *plus three times the actual damages caused* by the infringing acts. (970 S. 126).

License Agreements

A license contract may contain provisions that the heating contractor will pay a specified amount for the privilege of making, using or installing a patented device. If the contractor desires to pay for each use of the patented device, instead of a lump sum, the contract may so specify.

The license need not be obtained on an invention for which a patent is "applied for," because no person is liable for making, using or selling a device until *after* the patent is issued. In other words, although a device is stamped "Patent Applied For" or "Patent Pending" any contractor can make, sell or use the device at any time before the inventor obtains his patent.

Another important rule is that where a patent is obtained by two or more inventors, either inventor is privileged, without consent of the other, to grant a license or right to use the same. In other words, each co-inventor has the same right to make, sell and use the patent as if he were the sole owner.

License Privileges

A common source of litigation is where a contractor secures a license to make or install a patented device on one job and than later proceeds to use or install the invention on another and distinctly different job without obtaining a second license. The contractor always is liable for infringement where he fails to obtain a separate license for the second use. (91 F. 248). On the other hand, a contractor who has obtained a license to use or install a patented invention is not liable *for infringement* where he uses the invention and then refuses to pay the agreed license fees. The patentee's only recourse is to sue the contractor for the license fee. (206 F. 176).

However, if a contractor *offers* to purchase a patent, or take a license, or advance money for an interest in a new invention, he must carry out the complete terms of his agreement, otherwise the patentee may rescind the contractor's license or other privileges under the contract. (78 F. 487).

While an inventor cannot prevent any person from making, selling, or using his invention before he receives his patent, yet it is well established that when the patent is issued all unauthorized users are liable from that day as infringers. However, if the inventor either sells or licenses a person to make or use the invention before he obtains a patent, the license is effective after the patent is allowed.

For example, in Federal Construction Co. v. Park Improvement Co., 166 F. 128, it was disclosed that before an inventor obtained allowance of a patent he permitted a contractor to construct and use it. After the patent was issued the inventor sought to restrain the contractor from using the device. However, the court held that the contractor may continue to use the device and that no infringement existed, quoting the following law:

"Every person who purchases of the inventor or discoverer, or with his knowledge and consent constructs any newly invented or discovered machine, or other patentable article, prior to the application by the inventor or discoverer for a patent, or who sells or uses one so constructed, shall have the right to use, and vend to others to be used, the specific thing so made or purchased, without liability therefor."

It is important to know that a contractor who purchases patented equipment from a patentee or an authorized licensee in one state may without liability use the patented equipment *in all states in the United States.*

Legality of License Plates

It is well settled law that a purchaser of patented equipment is not bound or obligated by license notices or plates commonly attached to patented devices.

For illustration, in the leading and recent case of Straus v. Victor, 243 U. S. 469, it was disclosed that a manufacturer required each purchaser of a patented device to attach thereto a license plate which contained a notice that users of the devices were required to purchase repair parts for the device from the patentee. In holding the license notice void and of no effect, the Supreme Court of the United States said:

"It thus becomes clear that this 'License Notice' is not intended as a security for any further payment upon the machine, for the full price, called a 'royalty,' was paid before the plaintiff (patentee) parted with the possession of it... The scheme of distribution is... in substance and in fact a mere price-fixing enterprise, which, if given effect, would work great and widespread injustice to innocent purchasers, for it must be recognized that not one purchaser in many would read such a notice, and that not one in a much greater number, if he did read it, could understand its involved and intricate phraseology, which bears many evidences of being framed to conceal rather than to make clear its real meaning and purposes."

Right to Repair Patented Article

It is important to know that contractors, dealers, and other users may be held liable as infringers where extensive repairs are made on patented devices or if an attempt is made to rebuild a worn-out patented machine. However, this does not mean that a purchaser of a patented device may not make *minor* repairs. Generally speaking, the distinctive line which separates infringing and non-infringing acts in making repairs on patented equipment is whether or not the repairs actually consist of substantially reconstructing the machine.

For instance, in the leading case of Shickle, Harrison & Howard Co. v. St. Louis Co., 77 Fed. 739, the court clearly explained the law on this subject, as follows:

"The rule is well established that one who purchases a machine or mechanical contrivance consisting of several distinct parts, which as a whole, are covered by a patent, has the right, by virtue of his purchase from the patentee, to repair a part of the machine or device which happens to be broken through accident, or which becomes so worn as to render the machine inoperative, *provided the machine, as a whole, still retains its identity* . . . And provided, further, that the part so replaced is not separately covered by a patent . . . The rights to thus repair a patented device is incidental to ownership. The fact that it is patented does not lessen the owner's right to put it in order when it gets out of repair, *unless, considered as a whole, it is worn out and useless.* When a patented machine is accidentally destroyed, or when it is practically worn out, the owner thereof, under the guise of repairing it, cannot make a new machine. In such cases he must cast it aside and buy a new one from the patentee."

Radiant Heating With Air

With radiant or panel heating, the structure and solid objects within the buildings are heated first, and then the air. To provide the heat, water, steam, air and electricity have been used successfully in panels for floors, walls and ceilings. The work done with warm air in ceiling panels, and some of the results achieved, were described by H. F. Randolph, vice-president, International Heater Co., Utica, N. Y., in a paper, Panel Heating With Air, presented before the Midwest Power Conference. An 8-room test house provided with 175 thermocouples provided basic information.

The study into panel heating by means of warm air was made because the investigators believed that a less expensive means of panel heating might be developed for the low cost home, and because it was felt that air lent itself more readily to a form of radiant cooling.

In the type of installation employing warm air, only the ceiling panel was used, for the following practical reasons:

1. Only a limited space is available under a floor for the heating panel with the result that the friction loss is high.

2. Although a floor temperature above 85F might cause foot discomfort, a ceiling panel temperature of 115F is possible without any bad results. Therefore, about 50% more heat can be introduced through a ceiling panel than with a floor panel of the same unit area.

3. When the heat source is high, less convection currents are established.

4. There are no obstructions such as doors, windows or furniture when dealing with a ceiling panel.

5. Since a ceiling panel is generally constructed of a ¾ in. layer of lath and plaster, it is possible for the plaster temperature to more closely follow outdoor temperature changes.

A gypsum board partition is placed below the joists and attached to it. A metal lath and plaster ceiling is suspended 3¼ in. below this and warm air circulates through the intervening space. Galvanized strips are placed in this space to so direct the air that every part of the ceiling is reached by the warm air. Since the maximum temperature of air entering the panels is about 130F, the air leaving the panels is about 85F. About a 50% greater volume of air must be handled with this system than with forced warm air heating. However, since air is not discharged into the room, air velocities can be higher.

Controls for this system consist of the conventional room thermostat which actuates the firing device, and a bonnet thermostat which controls the operation of the blower. Occupants of rooms cannot detect temperature variations because of the rapid response of the ceiling panel to heat.

Ceilings can either be finished rough or smooth, painted or papered. Plaster in use over 6 years showed no indication of calcining or deterioration.

The greatest air movement in an average two-story house is down the stair well, particularly so if the second floor is underheated as related to the first floor. However, measurements taken in the stair wells of two 2-story houses heated with ceiling panels showed an air movement that was less than 50 fpm, a value considered as still air.

There is another interesting point. A greater degree of comfort is experienced adjacent to large surfaces of glass than with other systems. An explanation for this is that most of the heat rays that strike the glass are reflected back into the room because glass is opaque to infra red rays from a low temperature source.

Direct fired heaters are used with most of the warm air panel heating installations. However, two building plans are being developed that will use hot water through exchangers.

Experience is my Classroom

By T. W. REYNOLDS

GAGE GLASS ERRORS

Sometimes it happens that a gage glass will show a very unsteady water line, yet the water in the boiler may be quite steady. It all depends upon how active the boiler is at the point to which the gage glass is connected. In an installation of two round boilers, each had the gage glass too near a nipple port and in each glass the water rose and flooded the glass. One boiler was coal fired and had a 6 in. gage, the other oil-fired and with a 9 in. gage, but each gage glass was as flooded as the other regardless of fuel used or the height of the gage. All radiators heated without noise or evidence of priming and dry steam was discharged from each safety valve.

A steel boiler may show a steadier water line than a cast iron boiler does on the same job, particularly where there is evidence of carry over in the system. The gage glass in the steel boiler is located farther away from the point where water leaves the boiler, hence it shows a truer condition of boiler water line location.

KEEPING BACTERIA AT HOME

In certain drug manufacturing processes there are testing and other rooms where it is undesirable that any bacteria should leave one room and enter some other. The air can be returned to the air conditioning apparatus through the corridors in the usual way, but should first be screened as far as practical by filters one or two deep and placed at the top or bottom of each door to the corridor. The bottom location allows more convenience in servicing and should give the best air flow, but the top location may take stock sizes of 20 x 20 in. filters set in what would otherwise be the transom. When the filters need changing of bacteria, they can be removed and used at air conditioning apparatus in other buildings of the plant. Filters should preferably be of the strainer type.

Filters are not 100% effective for doors are loosely fitted or opened at times and there is exfiltration and infiltration to contend with. Where there is hollow glass blocks in exterior walls, there is not much infiltration from outdoors, so that practically all of the supply air must be forced out through the filters. This condition of pressure further tends to minimize infiltration from outdoors, but does not necessarily prevent infiltration to or exfiltration from an adjacent space.

As a rule each space must each have its own reheater for individual control. Sterile lamps may also be required in each space. Lamps can be located inside the space, but the reheaters and their pipes should be just outside.

DESIGN DATA ON PLANS

The plans of an old job about to be altered are before the writer. There is an absence of the real kind of information on them and still less in the specifications. Sizes are given, but capacities are missing. What a help now if the basis of that design were known!

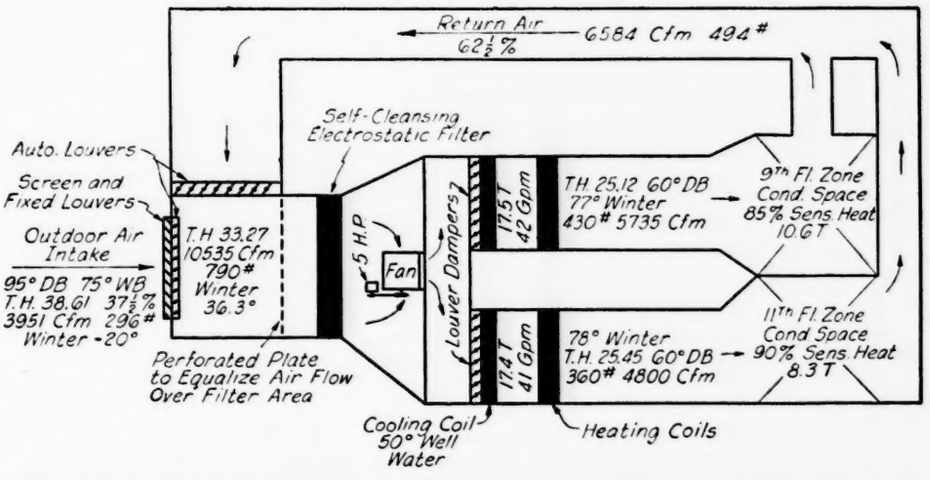
The writer likes to set down on his plans the generalities of the design, the cfm of each outlet and of each branch duct, the capacity and characteristics of all equipment and a sketch of the air conditioning diagram. The air quantities on the ducts save frequent additions as changes are made, the data on equipment saves hunting up the specifications, and the diagram is helpful when data get lost. In any event, it is always better to have all of the usual recurrent questions answerable from one source rather than from two sources (plans and specifications). As for the installer, he has as a rule only the drawing before him. If he did have the specifications, they would soon become soiled or shopworn, torn or lost.

The writer isn't afraid that someone will know too much about his design due to placing all of his cards on the table. As a matter of fact, this method has been of service on a couple of occasions where others have called attention to mathematical errors on the plans in sufficient time to apply the necessary corrections.

SUN EFFECT AND TANKS

Fishing alone amidst Adirondack silence for hours is restful, but when the low noise level is finally and suddenly broken at twilight, by a few booms from some unknown cause, it brings one out of his reveries with a start to recall some of the tall stories as told back by the camp-fire where the real hunting is done. Being an engineer, one investigates by rowing over to face the situation amongst the weeds along the wooded short line. There it is, just an abandoned gasoline drum that has been lost from its moorings miles away and is only doing a bit of contracting as the sun goes down behind the mountains.

Expansion of air in a tank from sun effect is one of those things to be careful about. Back in more civilized country, a tank of 10 ft diameter and 40 ft long was being pumped up for test in the presence of the inspector. It lost pressure as the air contracted with the sun's passing, so plenty of air was pumped in. Completion of the test was then held over for the next



DESIGN DATA ON PLANS: Diagrammatic arrangement of conditions at air conditioning apparatus, showing air conditions at various points. Each conditioned space to be 78F D.B.; 50% R.H.; 65F W.B.; 72 deg. ET; 30.06 T.H.; 70F winter.

day, but the sun got there first in the morning. A plug was then removed to let the expanding air out, then suddenly everyone fled the scene, for the air pressure rose on the gauge faster than it could be compensated for by the relief opening.

WASTE OF ENERGY IN INDUSTRY

In our trips across this country we note from our Pullman window the many industries with steam blowing to atmosphere, while here and there is one where the sky is momentarily lighted up by huge blasts of fire. The writer has pondered over this for years. Why should one industry produce a waste which some other industry could use to great advantage. Why should one generate power and waste steam while another produces steam only. Why not bring them together as one industry making two products, or as interconnected industries, to the end that the waste energy of one becomes the raw energy for the other.

These idle speculations of former days upon the part of the writer have become the basis for serious thought in certain circles. There are so many additional advantages to be obtained, such as flexibility, elimination of banked fires, utilization of flash steam and condensate from process and the uniformity of steam demand and pressures. Less equipment need be installed merely to provide for peaks of short duration, while the diversity factor with two or more interconnected industries reduces the amount of boiler plant equipment otherwise required for several small plants. These are but a few of the advantages that tend to produce a high overall efficiency.

ENCOURAGING YOUNG MEN

The young man's interest in engineering should be encouraged in every way so that the organization they are in will be alive and grow. Responsibility, or at least the appearance of responsibility (with one weather eye on guard), should be thrown upon them. They should be taken out in the field and allowed to make minor decisions.

In my opinion, young men should be encouraged to write for publication. I started in at 28 years of age and, much to my surprise, the first item was accepted. Technical writing requires knowledge first and ability to write second. Editors will do the necessary editing if the article has technical merit. Most any engineer, no matter how young, has experienced some application of interest. Writing improves vocabulary, increases knowledge, and makes one more useful back in the drafting room.

You have only to write about some familiar thing suddenly to find out that there are phases of the subject you had never thought of before and concerning which you could well know more and then set out to supply the deficiency. Write a good article and few will tell you they saw it, but make one slip and you will be surprised how many people read magazines.

Data books have been jokingly called a collection of information nobody wants; nevertheless, the young engineer should keep one. He should read the technical magazine in his field. Also, much can be gained by acquiring a catalog file and becoming informed on its contents.

Listening to the various salesmen is a good education. Too many engineers try to tell the salesman when they should be listening instead. Let the salesman ferret out the things which could be wrong in the other fellow's product and you will learn all the angles. Seriously, the salesman is a specialist in his line and an expert in trouble hunting. All of the problems peculiar to his specialty are dropped in his lap for him to solve.

A checker has been defined as a man with a blue pencil and no conscience, but what is better than to find out where you are wrong, hard as it may be to take it. It's a good plan to try out young men as checkers, even though someone more experienced does the final checking. It's great fun finding things that are wrong, rather like a treasure hunt, and it is a great education to yourself. You learn what engineers tend to neglect, the things automatically to watch for in your own design.

Tell the young engineer the full story to interest him. Older men are sometimes hesitant to do so, though any leader with average ability can retain his position without fear that the younger man will supplant him in time. The older man has access to the top management, gets his information direct and gets it first. He should have nothing to fear and should not hide either his data books or his experience.

MADE TO BE CHANGED

The young college graduate does not understand that drawings are made to be changed and that a record plan made in the field after installation is complete would show numerous other changes. This is even more true today when scarcity of materials and over budget costs make continual revisions necessary.

Engineering costs go up accordingly, though there are some compensations, for much equipment must now be quickly bought as is and where it can be obtained without elaborate specifications, several bids, much correspondence, and many conferences. Price does not particularly matter as long as there are escalator clauses in every contract and work is on the cost plus basis.

VACUUM PUMPS AND BREAKERS

It has been said that a vacuum pump is needed only on a long drawn out horizontal layout and not on a tall building. A tall building is certainly drawn out vertically and both types of layouts can be bettered in operation by a higher differential at radiator traps. Condensate returns by gravity in both cases but, regardless of the structure, a vacuum pump is a valuable asset along other lines. It is needed for starting up in the morning, during which time the fires can be cleaned, yet steam can meanwhile be circulated.

When there is a vacuum pump around, everyone wants to use it in an unorthodox way. Overhead returns for example, should never be connected to a pump on the pump side of a lift fitting. The hydrostatic head will favor the overhead return.

The vacuum breaker on a domestic hot water heater is another matter. Why not connect it to the pump? Of course this serves no useful purpose when the pump is not on vacuum duty; for example, when switched over to night operation, it serves merely as a condensate pump. However, if this is done, it should be done properly by running the pump at 12 in. of vacuum instead of the normal 6 in.

This is necessary so as to lessen the liability of the vacuum breaker leaking air back to the pump under high vacuum, since the vacuum in the heater may go to 25 inches whenever the heater control shuts off steam. Where heater coils are properly drained, the installation of a vacuum breaker is of doubtful value.

PSYCHOLOGY AND EQUIPMENT

Few people have the means, time, or inclination to find out what benefits are obtained from a particular device after installation. Which brings to mind one instance of the last word in filtration as installed within a certain structure. Six months later the salesman visited the plant and everyone conceded that a wonderful job had been done, in fact, so much so that they sold the salesman on his own product. So the salesman took a second look at the apparatus to find out the wherefore, only to learn that for certain reasons the apparatus had long since been shut off by someone and never started again.

Which makes one stop and ponder on how we specify this or that, receive no complaints, and then from a negative experience conclude in a positive manner that the thing is O.K. We go right on repeating our specifications, design and mistakes as long as we do not hear from the job, but it is the complaints that give us the most experience.

NOTES ON PIPE AND FITTINGS

Iron pipe in sizes ⅛, ¼ and ⅜ in. costs the same but is cheaper than pipe of ½ in. size, while lap-weld wrought iron pipe costs more in the 1¼ in. size than it does for 1½ in. The labor on the lap is greater on the smaller size.

Extra heavy fittings are sometimes used at change of direction in pipe lines with the idea that these will better take the thrust of expansion. The user forgets, however, that the pipe itself is weakened by the thread and will break before a fitting of standard weight would.

In figuring the linear feet of pipe required for long lines, users should make allowance on pipe fitted with threads and couplings for the distance that the pipe will screw into the couplings when assembling in the field. The customary rough allowance is one half the length of the coupling.

HOW AIR COMES AND GOES

How the air comes and goes in a conditioned open industrial space may be picturized by arrows, but the path it really takes is best determined by the feeling in your marrows after the installation is completed. For the sake of discussion, however, it will be necessary to revert to the primitive arrow, so as to show the course of the air and to mark its landing place.

Consider first, sketch *A*. Whether it is summer or winter, conditions will be as shown, except that the ducts will handle hot air in the winter time. To keep the south side from being too hot, the north side will be too cool, both in summer and winter. There will be drafts near the common central return and this return will be expensive for it is underground and insulated.

Putting the return overhead as in *B* will save expense, but the previously drafty area now changes to stagnant, for the supply air short circuits to overhead return, and the feet will be too cold. Still keeping the return overhead, but to one side, as in *C*, the conditions remain practically unchanged. Putting the supply ducts overhead with a bottom side wall return still doesn't help or produce much change, whether done by any of the methods *D* to *H* inclusive. With all these methods, there is a definite unbalance in cooling and heating and a variance in temperature. It is impossible to control such systems automatically with a zone type thermostat. Continual resetting of controls is required.

Sketch *I* then seems to be the answer for satisfactory conditions. In winter the ducts on the north and east walls supply heated air while the ducts on the south and west walls return it to the air conditioner. The heated air shields and curtains the cold walls and windows from the rest of the room. By blowing this air at high velocity up against the window panes it minimizes condensation where high humidities must be held. By the time this air reaches the other side of the space it lowers in temperature, as required on the other side where there is less heat load in winter.

In summer the conditions are reversed from those as shown. The return ducts on the south and west walls now become the supply ducts (but now handle cooled conditioned air), while the ducts on the north and east walls return this air. The cool supply air absorbs the heat gain at the windows. By the time this air reaches the other side of the space it rises in temperature as required on the side where there is less heat gain in summer.

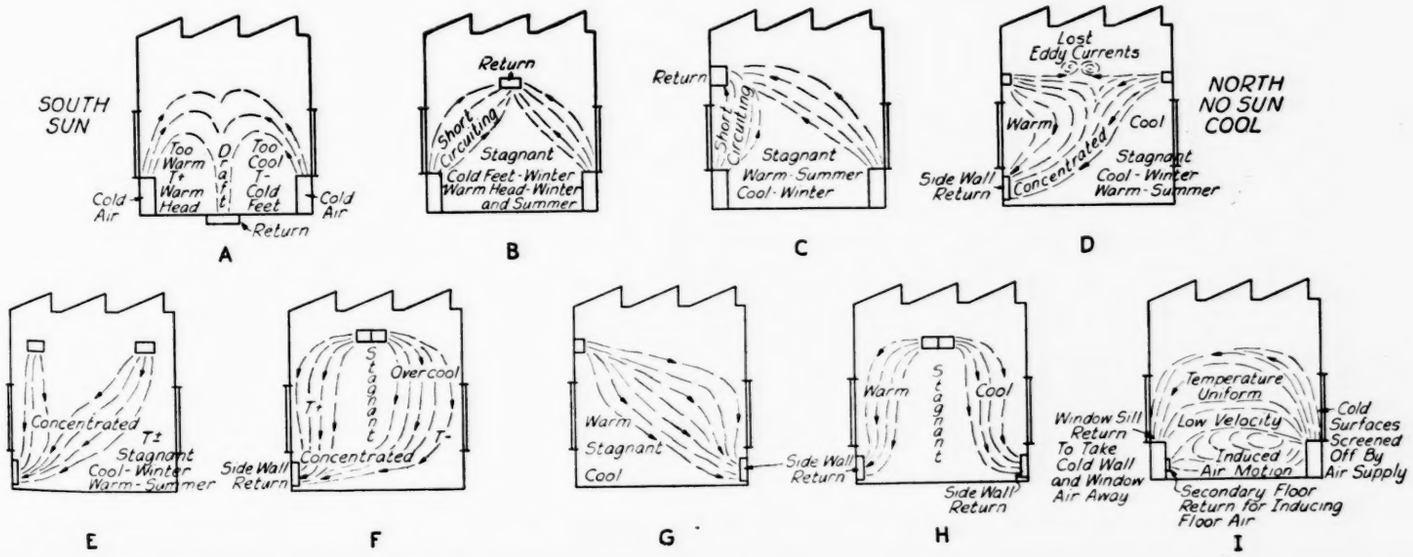
Both in summer and winter the air returns at the floor level to a return run the entire length of the building, so as to give uniform and quick removal of the air, though at low velocity. In this connection, it should be noted that drafts are not due to slightly cooled air returned at floor level, but rather to air which stagnates so long in contact with a cold ground floor that it becomes extremely cold.

This method, *I*, is more expensive if enough grille area is provided so as to cover the window and wall areas effectively. Lower air velocities at the floor, so as to diminish floor drafts, also call for more duct work. Separate zone controls for summer and winter are further items of additional cost. On the other hand, the advantage of separate summer and winter controls is provided and the air conditioning equipment can be sized for comfort conditions for both summer and winter. This method will minimize drafts and logically should give more uniform temperatures over a greater portion of the space than any of the other methods shown.

THE RECENT GRADUATE

From the standpoint of the employer, it is to be expected that the young college graduate will have some drawbacks. You can't go away on a vacation and leave him to run the place. He may at first take a week to do what you could do in a day if you could spare that day and he may suddenly do something decidedly unorthodox if he hasn't met some particular phase of a problem before. Some are impetous and rush in where angels fear to tread and most of them are lost on a simple calculation if their slide rule is misplaced. This rule was long their faithful companion in the class room.

One thing they will most likely do is to question everything. It's rather hard on your nerves and your ego, but it's a healthy sign, a sign that they will become good engineers, for they take nothing for granted. The best men I have known were the ones who questioned the most.

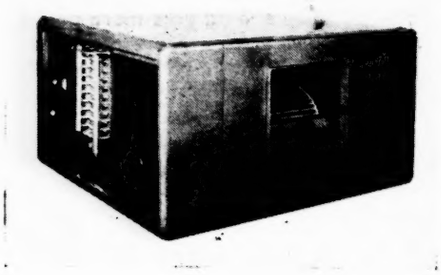


HOW AIR COMES AND GOES: Air flow diagrams for an open industrial space. Sketch is the preferred method.

NEWS OF EQUIPMENT AND MATERIALS

Air Conditioner

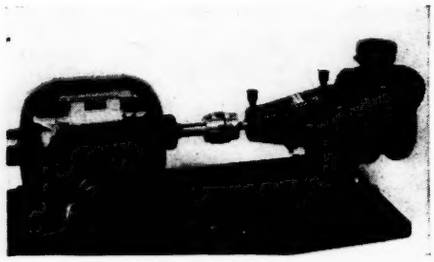
NAME—McQuay year 'round air conditioner.
PURPOSE—For space heating and cooling of stores.
FEATURES—Unit may be suspended from the ceiling or mounted on



regular store fixtures. Both the direct expansion cooling and the water cooled types are available with air discharge duct flange connections to duct work. Cooling and heating coils are non-ferrous tubes with aluminum fins. Multiblade forwardly curved, double inlet fan is used, belt driven, with drive pulleys to provide several operating speeds. Unit has standard sleeve bearing resilient base motor for quiet operation. Conditioner has throw-away type filters.
LITERATURE AVAILABLE — Bulletin 83A-0-5-47.
MADE BY — *McQuay, Inc., 1600 Broadway N. E., Minneapolis 13, Minn.* **515**

Turbine Pump

NAME—Eagan turbine pump.
PURPOSE—For the movement of clean liquids up to 500 SSU viscosity.
FEATURES—Both inner and outer



heads of pump are renewable without disturbing bearings, shaft or pump alignment. Impeller is of the peripheral type and is balanced to eliminate end thrust. Shaft is of 18-8 stainless steel. Unit has one stuffing box. All models have shafts and bearings suitable for belt drive.
SIZES AND CAPACITIES—Capacity up to 250 gpm and pressure up to 200 lb per sq in.
MADE BY—*Walter H. Eagan Co., 2336 Fairmount Ave., Philadelphia 30, Pa.* **516**

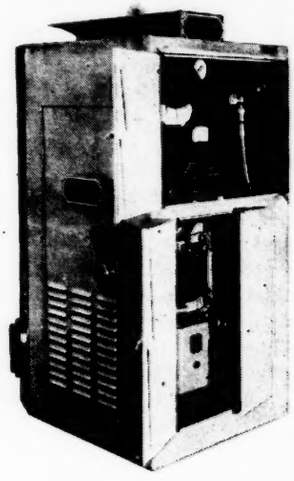
Suspended Chimney

NAME—Van-Packer flue.
PURPOSE — An all-fuel chimney which can be suspended from the ceiling or floor.
FEATURES — Chimney consists of a

7-in. diameter high temperature acid proof tile lining with a 3-in. wall of lightweight insulating cement, steel reinforced. Above the house roof there is a design for automatically counter flashing to the roof, and a masonry chimney cap. Makers claim that since chimney is light enough to be suspended from the ceiling or floor, it is an integral part of the house and cannot settle to cause wall cracks. The product has been tested and approved by the Underwriters Laboratories. These tests showed that the chimney has a heat capacity equal to or greater than a lined brick chimney; that surface temperatures are well below ignition temperatures of wood, even under severe firing conditions and that the liner, insulation and joints are not adversely affected by extreme overfiring. The flue consists of precast circular sections 2 ft or less in length and each section comprises a chimney tile liner surrounded by a 3 in. masonry wall reinforced by expanded metal binder. Flue is intended for use in dwellings up to two stories high.
MADE BY—*Van-Packer Corp., 140 S. Dearborn St., Chicago 3.* **517**

Drying Unit

NAME—THAG No. 1 model.
PURPOSE—For supplying quantities of heated air at controllable air velocity and temperature.
FEATURES—Electric motor is 5 hp



which operates at 3450 rpm to drive a fan of 1000 cfm capacity; 10 in. air pressure. Combustion chamber burns gasoline, kerosene or Diesel oil at the rate of about 1.25 gal per hr when temperature of delivered air is 200F. Temperature of exhaust air may be regulated from 200 to 350F. Unit has a 6½-gal fuel tank which is said to be of sufficient capacity to operate the heated air generator for 5 hr. Unit is complete in itself except for a source of electric power. Unit has the Todd combustion chamber which was developed during the war for jet propulsion.
SIZES AND CAPACITIES—The No. 1 model is illustrated. No. 10 unit has a capacity for delivering 10,000 cfm of 350F air. Weight is 1,200 lb.
MADE BY—*Todd Shipyards Corp., 81-16 45th Avenue, Elmhurst, N. Y.* **518**

Prefabricated Convectors

NAME—Warren Webster concealed convectors.
PURPOSE—Concealed convector unit for space heating.
FEATURES—In a single unit is combined the heating element, supply

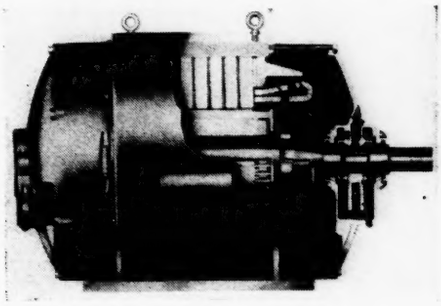
valve, thermostatic return trap and union connections. Heating element is contained in a sheet metal enclosure with openings at top and bottom for air movement. Provision positive control of heat is made by extending the supply valve handle through the enclosure. To reach the heating element of concealed convector it is only necessary to remove handle of control valve and four wood screws, and withdraw baseboard. Enclosures are made of furniture steel and are finished in a baked prime coat. While unit can be used with a vacuum or open return steam system, it cannot be used with hot water heating or one pipe steam systems.
LITERATURE AVAILABLE — Bulletin 1500-C.
MADE BY—*Warren Webster & Co., Dept. HV, Camden, N. J.* **519**

Stack Coating

NAME—Amercoat No. 1132.
PURPOSE—Stack coating to withstand high temperatures.
FEATURES—Based on silicone resins and specially formulated, makers claim that this coating which is designed for boiler breechings and stacks, will withstand temperatures as high as 600F; that it has good resistance to chemical conditions and weathering.
MADE BY—*American Pipe & Construction Co., P. O. Box 3428, Terminal Annex, Los Angeles.* **520**

Induction Motor

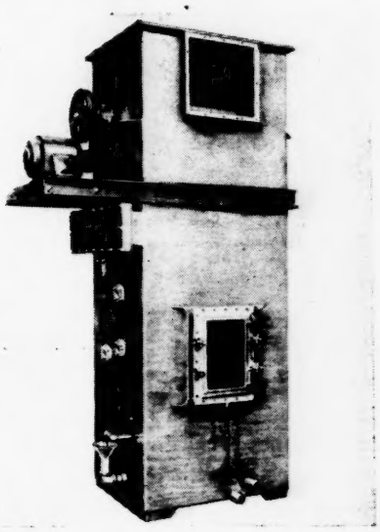
NAME—E-M two-pole squirrel cage induction motor.
PURPOSE — Motor for high speed applications such as boiler feed pumps, centrifugal pumps, compressors and blowers.
FEATURES—Two specially designed centrifugal fans provide ventilation to working parts of motor. Makers claim that fan design has reduced windage noise to a minimum. Motor has Kolene process centrifugally cast bearings. Unbolting upper half of split bearing bracket gives access to bearing



sleeves. Cage structure is designed so expansion and contraction are within the elastic limits of the metal.
MADE BY—*Electric Machinery Co., Minneapolis 13, Minn.* **521**

Air Conditioner

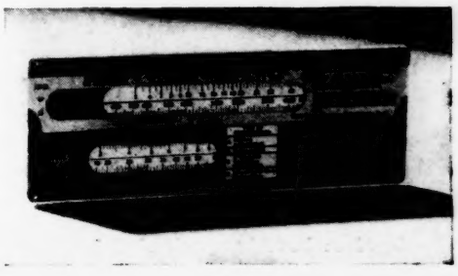
NAME — Niagara Type-A air conditioner.
PURPOSE — For producing air conditions of exact relative humidity and temperature.
FEATURES—Conditioner has a casing of stainless steel welded into an integral unit. Unit functions by saturating air with moisture at a given desired dewpoint and then by reheating, producing desired air conditions. Makers claim that temperature conditions between 40 and 125F can be held with close tolerance. Lower temperatures can be obtained by using a non-freezing liquid in the spray solution.
SIZES AND CAPACITIES—Unit illustrated occupies 7.5 sq ft and deliv-



ers 2,000 cfm. Other models occupy 50 sq ft and deliver up to 20,000 cfm.
MADE BY—*Niagara Blower Co., 405 Lexington Ave., New York 17, N. Y.* **522**

Heat Calculator

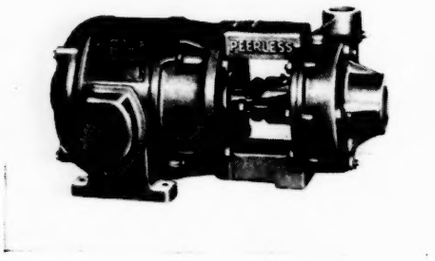
NAME—Superfex Btu calculator.
PURPOSE — For rapidly estimating the total heat loss of the average building.
FEATURES—Use of this calculator is based on length, width and height of the room or dwelling, type of construction, and outside design temperature. Calculator is designed to help the builder or contractor to rapidly determine the size of heating system required.
MADE BY — *Perfection Stove Co., Cleveland, Ohio.* **523**



Centrifugal Pump

NAME—Fluidyne centrifugal pump —type PE.

PURPOSE — For the general movement of water and other liquids against heads up to 270 ft.



FEATURES—Unit is integrally coupled in which the pump and driving motor are anchored on the motor footing. Motor bracket forms back plate for volute case. Shaft sleeves are stainless steel. While drip proof motors are standard, totally enclosed and explosion proof motors can be furnished. Fitted to the shaft is a water deflector to protect bearings from fluid being pumped.

SIZES AND CAPACITIES—Up to 1,000 gpm against heads up to 270 ft. Drives, fractional to 20 hp.

LITERATURE AVAILABLE — Bulletin No. B-165.

MADE BY—*Peerless Pump Division, Food Machinery Corp., 301 West Ave. 26, Los Angeles 31.* 524

Snap-in Filter

NAME—Research snap-in grids.

PURPOSE—Simple method for maintaining an efficient filter bank.

FEATURES—Grid is made of wire steel with rubber tips. It fits in front of the filter and secures filter to multiple frame. Although grid holds the filter tightly in place, it can be snapped out of the filter bank by means of an easy pull. Filter is made without an outside frame and consists of layers of sheet fiber which are slit and expanded into tiny baffles. Sheets are adhesive treated to catch and hold the dirt. Each square foot of frontal area is made up of 25 sq ft of dust collecting baffle areas.

LITERATURE AVAILABLE—Illustrated folder.

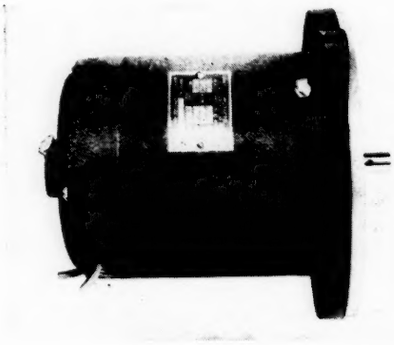
MADE BY—*Research Products Corporation, Madison 3, Wis.* 525

Fractional HP Motor

NAME—SM-5 motor.

PURPOSE—For operating gun type oil burners.

FEATURES—Motor is supplied with NEMA oil burner flange mounting, also resilient and rigid base mountings. Unit which may be wound for split phase, capacitor or polyphase, is furnished with sleeve bearings. Motor may be wound for speeds of 1130, 1725 or 3450 rpm.



SIZES AND CAPACITIES—In sizes up to ⅛ hp. Diameter, 4¾ in.

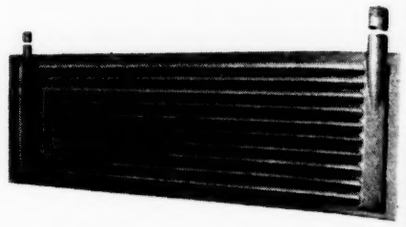
MADE BY—*Small Motors, Inc., 2076 Elston Ave., Chicago, Ill.* 526

Heat Transfer

NAME—Platecoil.

PURPOSE—To provide a flat interior surface in heated tanks for heat transfer.

FEATURES—Construction eliminates the need for internal tubing and is said to reduce the weight per square feet. The flat surfaced plates



can be formed and welded as part of the tank bottom, side walls, or both. Makers claim that less plate area is required than with conventional designs. Should repairs become necessary, unit can be removed and replaced without the tank being out of service for a long time. Unit is provided in steel with metallized surface of various metals, or in Monel and stainless steel.

MADE BY—*Platecoil Div., Kold-Hold Manufacturing Company, Lansing, Mich.* 527

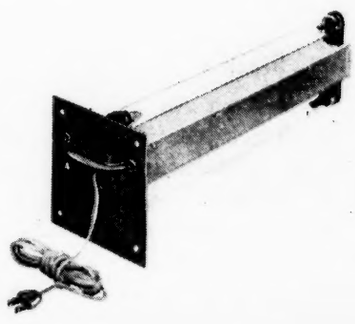
Air Purifier

NAME—Sterilator.

PURPOSE—Home air purifier unit.

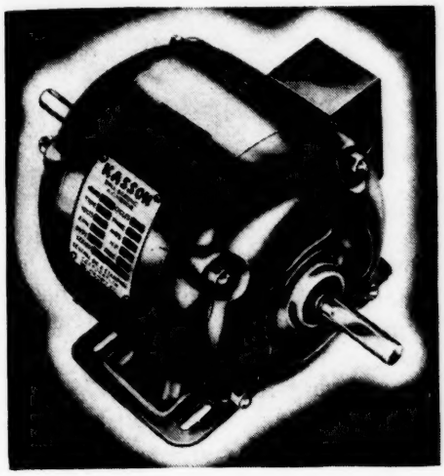
FEATURES—Unit uses the G-E germicidal lamp. It is said to be easily installed in the heating and air conditioning system within the home and since it is within the stream of air supplied to the various rooms of the house, the largest part of the air-borne bacteria are destroyed.

MADE BY—*Domestic Devices, 1495 Warrensville Rd., Cleveland.* 528



Fractional HP Motor

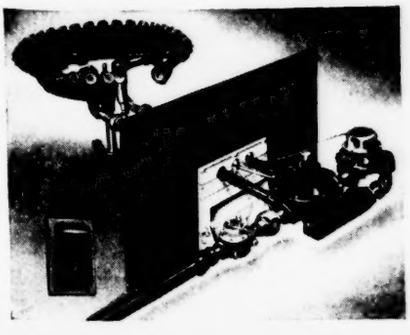
NAME — Kasson ball bearing a-c motor.
PURPOSE—For general purposes requiring a fractional horsepower motor.
FEATURES—Ventilation air is drawn from both ends of motor through



housing and exhausted at the center of the motor through radial louvers. Split phase motors have glass insulated starting winding for increased life.
SIZES AND CAPACITIES — 1/3 hp available in split phase, three-phase and capacitor start; ½ hp motor available only in three-phase. Operate at 110 volts a-c, 60 cycles, 1725 rpm.
MADE BY—*General Die and Stamping Co., 262 Mott St., New York 12, N. Y.* **529**

Gas Conversion Burner

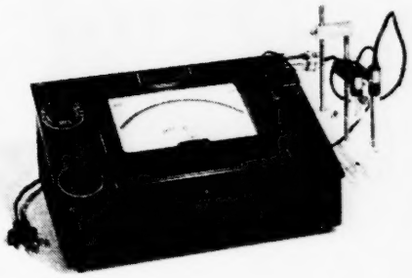
NAME — Miller Heater gas conversion burner.
PURPOSE — For converting a coal-burning furnace to the use of gas.
FEATURES—Unit has a large burner



diameter with 30 jets around its outer edge. Makers claim that this brings the burners to within 2 in. from the inside wall of the fire box to provide high efficiency. Burner is equipped with safety controls, automatic gas valve, automatic gas regulator, automatic safety pilot.
MADE BY—*Miller Gas Heating Co., 549 W. Washington Blvd., Chicago 6, Ill.* **530**

Electronic pH Meter

NAME — Photovolt electronic pH meter.
PURPOSE—Laboratory type instrument for measuring complete pH or acid and alkalinity range.
FEATURES—Instrument has a 7 in. scale and mirror for high precision readings. Unit operates directly on any a-c power line of 50-60 cycle frequency. A voltage selector makes it possible to use it on any vol-



tage between 90 and 275 volts. Unit is stabilized for line voltage fluctuations. Instrument can be used for continuous indication in titration work. Fully shielded glass electrode that comes with unit can be used some distance away or at the instrument.
MADE BY — *Photovolt Corp., 95 Madison Ave., New York 16*..... **531**

Blower Wheel

NAME—Revcor blower wheel.
PURPOSE—Blower wheel developed for use in oil burners, stokers and air conditioning applications.
FEATURES—Although made of steel, the method of construction employed also permits wheels to be made of brass or aluminum. Unit has a large number of thin gauge full width blades of the proper curvature and depth to provide maximum air contact for each diameter wheel. No rivets are used for holding the blades. Blade tips are expanded and rigidly locked in slots of the inlet ring and back

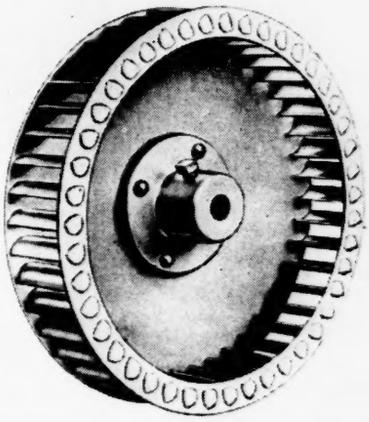
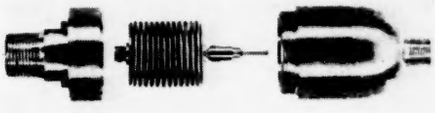


plate. Hub is riveted to the back plate of the wheel.
SIZES AND CAPACITIES — Available in diameters of 5, 6, 7, 8, and 9 in., and in widths from 1 to 6 in.
MADE BY—*Revcor, 3227 W. Carroll Ave., Chicago 24, Ill.* **532**

Vent Valve

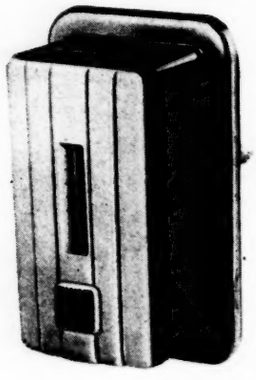
NAME—Risselt J-7 air eliminator.
PURPOSE — High pressure vent valve for industrial applications.
FEATURES—Valve is built of 2⅛



in. brass bar stock. Functioning mechanism is a 1¼ in. 12-convolution thermostatic bellows of Monel metal. Should the valve seat become damaged, it can be readily replaced at low cost.
MADE BY—*Lodge & Shipley Company, Risselt Division, Cincinnati, Ohio.* **533**

Thermostat

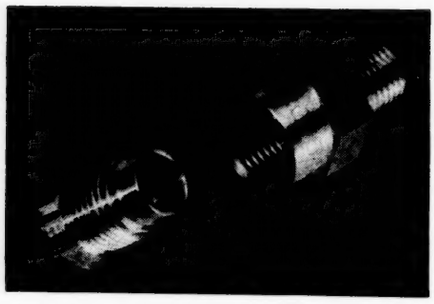
NAME—Barber-Colman unit heater thermostat.
PURPOSE—Control for cooling or heating service.



FEATURES—Adjustable stops are available so that lock settings can be obtained and operating range limited. Contact rating is 10 amps at 115 volts, 5 amps at 230 volts. Unit measures 2 x 4 x 1½ in. The heating range is from 40 to 80F; cooling 55-95F.
LITERATURE AVAILABLE — Bulletin F-3141.
MADE BY—*Barber-Colman Co., Rockford, Ill.* **534**

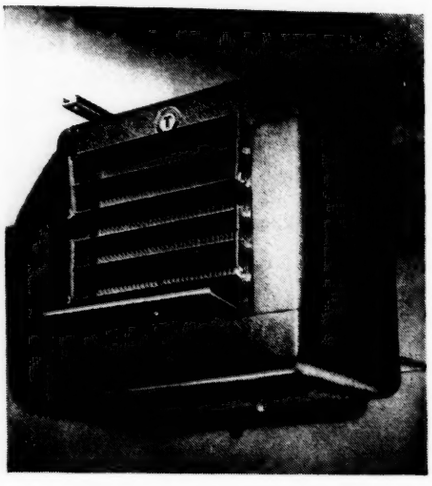
Tube Joint

NAME—Uniflare.
PURPOSE — A two-piece self-flaring fitting for joining tubing.
FEATURES — Tubing is correctly flared during the make-up of the coupling. Design of the fitting provides a sudden increase in torque when the joint has been completed. The nut has a thrust collar. The first fractional turn of the wrench shears the collar from the nut and during subsequent wrench operation, the nut acts as a ram to compress the thrust collar around the tube to form a flare.
SIZES AND CAPACITIES — In sizes from ⅛ to ⅝ in. O. D., in a range of styles and shapes.
MADE BY — *The Brockway Co., Naugatuck, Conn.* **535**



Cooling Unit

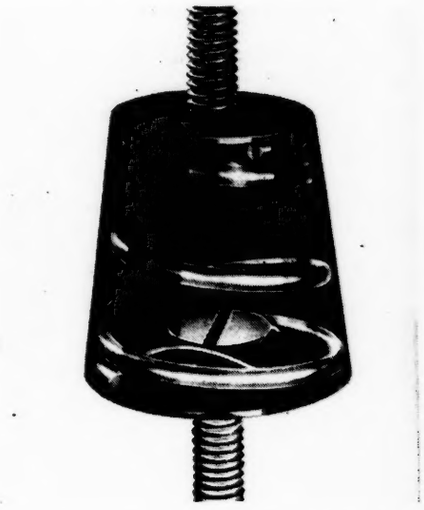
NAME—Tenney unit cooler.
PURPOSE—Space cooler.
FEATURES—Makers claim that this unit may be used either for comfort cooling or commercial refrigeration without the necessity of providing drip pans.



SIZES AND CAPACITIES—For cooling spaces up to 15,000 cu ft. Unit sizes range from 19¼ x 19½ x 12½ in. to 43 x 23½ x 12½ in.
MADE BY — *Tenney Engineering, Incorporated, 26 Avenue B, Newark 5, N. J.* **536**

Vibration Control

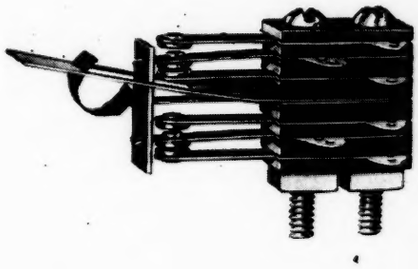
NAME—Korfund Type RS conical rubber-spring mounting.
PURPOSE—For the elimination of vibration in mechanical equipment.
FEATURES—Unit has a load capacity ranging from 25 to 125 lb per unit. Conical spring design is said to provide greater horizontal stability than conventional all-rubber mountings. Unit is said to be equally as effective for pumps operating at 1750 rpm as well as compressors running at 450 rpm.



LITERATURE AVAILABLE — RS bulletin.
MADE BY—*The Korfund Co., Inc., 48-33 32nd Place, Long Island City 1, N. Y.* **537**

Switch

NAME — Acro 2-pole open-blade switch.
PURPOSE—To provide a compact snap-action open blade switch for 2-pole applications.
FEATURES—Switch is constructed of beryllium rolling spring and is made with both single and double throw contacts. Standard operating pressures are from 3 to 5 oz. Rated at 15 amps, 125 volts a-c. Movement differential is about 1/16 in.



SIZES AND CAPACITIES—Overall dimension, 2 1/8 x 25/32 x 3/8 in.
MADE BY—*Acro Electric Co., 1391 Superior Avenue, Cleveland 14, Ohio.* **538**

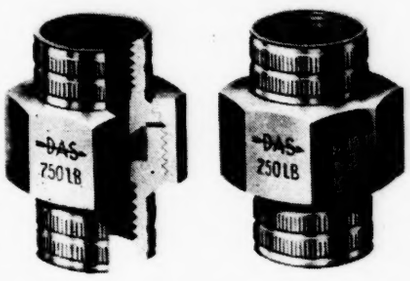
Finned Tubing

NAME—Finco.
PURPOSE—Coils to facilitate heat transfer.
FEATURES—Flat or pancake coils are formed out of tubing with ser-

rated fins. Flat coils are available in either ferrous or non-ferrous materials in a wide range of tube sizes, fin heights, fin spacings and coil diameters.
MADE BY—*Fintube Coil Corp., 19 W. Main St., Alhambra, Calif.* **539**

Test Union

NAME—DAS test union.
PURPOSE — Designed for use with low or high pressure piping.
FEATURES — Union is made from



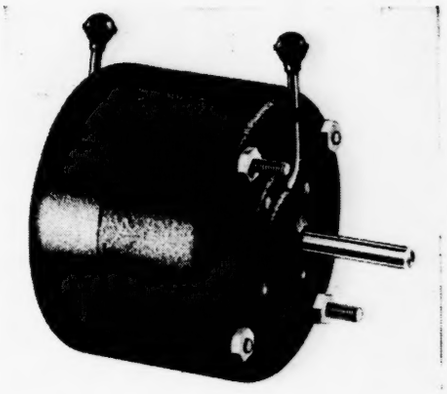
special carbon steel bar stock. Each piece is precision machined for 750 lb pressure. Brass seat is designed, makers say, to resist wear and corrosion.
SIZES AND CAPACITIES — Available in sizes up to and including 1 in.
MADE BY — *Defiance Automatic Screw Co., Ft. Wayne Rd., Dept. 7, Defiance, Ohio.* **540**

Insulation

NAME—Fiberglas high-temperature insulating felt.
PURPOSE — Insulating material in felt and bulk form to withstand high temperatures.
FEATURES — Material which comes in felt or bulk form is composed of specially processed glass filaments. In thickness of 0.125 in. the weight is 0.047 lb per sq ft. The *k* values for material of 6 lb density at 1700F is 1.65 and for material of 9 lb density, 1.33. Material is said to be unaffected by repeated heating and cooling and is non-corrosive to metals with which it may come in contact.
MADE BY — *Owens-Corning Fiberglas Corp., Toledo 1, Ohio.* **541**

Small Motor

NAME — SP-37 fractional horsepower motor.
PURPOSE — Motor designed for use with pot type oil burners.
FEATURES — Motor is the shaded pole type without brushes, commutators or slip rings. It is available with or without internal ventilating fan, and can be made ventilated or completely enclosed. It operates without radio interference.
SIZES AND CAPACITIES — From 1/100 to 1/60 hp. Operates 1650 rpm at 115-volt a-c.
MADE BY—*Small Motors, Inc., 2076 Elston Ave., Chicago, Ill.* **542**



Roofing Nail

NAME — Gora-Lee weatherproof roofing nail.
PURPOSE—To prevent leaks around roofing nails resulting from weathering and electrolysis.
FEATURES—Nail has a neoprene washer which forms a seal between the head of the nail and the metal sheathing and roofing. Makers claim that the neoprene will not harden and chip as the result of the cold, no get soft when exposed to the heat.
MADE BY—*Gora-Lee Corp., Stratford, Conn.* **543**

SEPTEMBER, 1947

TO OBTAIN FURTHER INFORMATION ON NEW EQUIPMENT

On the list below, circle the item number of the equipment in which you are interested. using the number found at the end of each item.

515	516	517	518	519	520	521	522
523	524	525	526	527	528	529	530
531	532	533	534	535	536	537	538
539	540	541	542	543			

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Abstracts AND Reviews

Publications abstracted in this department should be ordered direct from publisher.

SHEET METAL LAYOUT

From years of association with the sheet metal trade, the author has prepared a book designed primarily as a text book in vocational schools where pattern layout is taught. The book contains the minimum amount of text but is profuse in illustrative patterns for specific applications so that the student can see how special patterns are developed.

It covers the great variety of joists, transitions, elbows, stacks, etc., found in round duct work. The method of presenting the material is the result of years of both practical and teaching experience, and is the first part of a two-volume work. The second volume which is to be published will cover problems involving triangulation while the present book deals with parallel and radial line developments.

Short Cuts for Round Layouts, by Joseph Kaberlein. Cloth bound, 6 x 9 in., 269 pages. Published by The Bruce Publishing Co., 540 N. Milwaukee St., Milwaukee, Wis. Price, $3.75.

NDHA PROCEEDINGS

Reports of the various committees of the National District Heating Association and proceedings of the thirty-seventh annual meeting of the association held at Virginia Beach, Va., June 3-6, 1946 are now available in a bound volume. It contains the reports of 19 committees as well as information about the NDHA.

NDHA Official Proceedings, Vol. 37. Cloth bound, 6 x 9 in., 240 pages. Published by the National District Heating Association, 827 N. Euclid Ave., Pittsburgh 6, Pa. Price, $5.

AIR CONDITIONING AND ELEMENTS OF REFRIGERATION

With the absence of extensive and higher mathematics, the author shows how to calculate heating and cooling loads, and cool, ventilate and air condition buildings. It also covers selection of equipment, automatic controls, the design of air ducts and piping, refrigeration theory, and the selection of equipment.

Samuel P. Brown who prepared the book as a course in air conditioning at the Delehanty Institute, a vocational training course for students of high school education, was chief instructor, Vocational Division of that institute. Therefore, he has included necessary tables and data for elementary design work and has avoided what might be considered as complex theory. The understanding of fundamentals has been emphasized so that the student is enabled to make an intelligent selection of the proper equipment for the specific job. Since the actual design of air conditioning equipment and units requires engineers with considerable specialized experience and college training, such design details have been avoided in the book.

However, a commendable part of this volume are the many problems at the end of 11 of the 27 chapters, and the illustrative problems used throughout. At the end of the book are detailed answers to the problems used for review at the end of chapters.

The book is recommended for those entering the air conditioning field.

Air Conditioning and Elements of Refrigeration, by Samuel P. Brown. Cloth bound 6 x 9 in., 644 pages. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. Price, $6.

SHEET METAL MATHEMATICS

Instruction in the use of mathematics that might be required by the man in the sheet metal shop, is presented in an attractive, direct manner so that the man who has not had an advanced formal training in mathematics, might benefit from the text. While there are many other books dealing with shop mathematics, the basic principles of this book have been directed to apply to every-day problems in the sheet metal field. Problems given were selected from the fields of arithmetic, algebra, plane geometry and trigonometry.

The pattern of the book is to cover basic principle units with an explanation of the mathematical principles and formulas and then through sufficient problem material to provide some mastery of the principle.

Sheet Metal Mathematics. Spiral bound, paper cover, 8 x 10 in., 263 pages. Published by Delmar Publishers, Inc., Orange St. and Broadway, Albany, N. Y. Price, $2.75.

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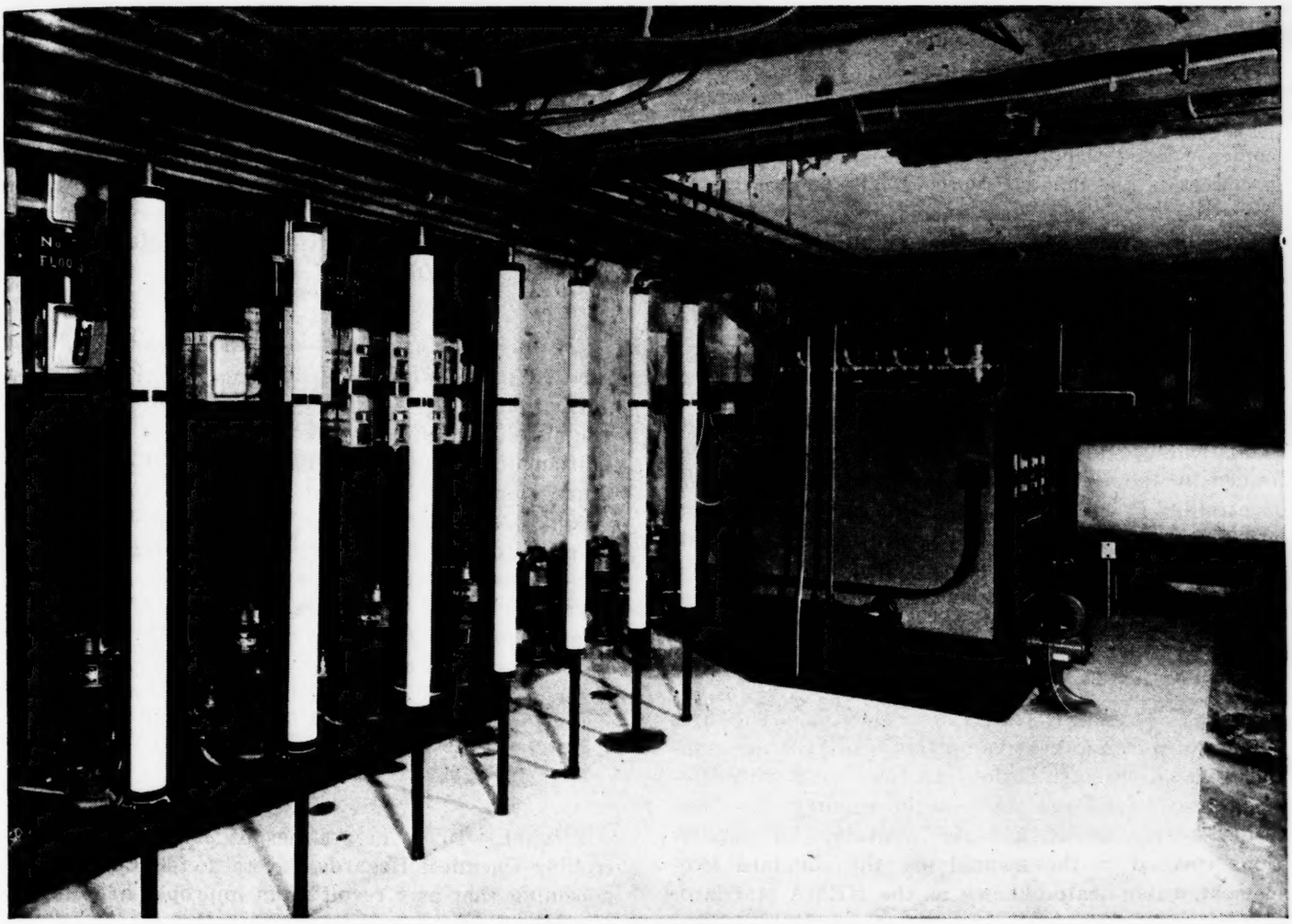
LOW TEMPERATURE INSULATION — As a service to consumers and the trade, the Industrial Mineral Wool Institute has published a 24-page manual on Holding Low Temperatures With Better Insulation. It contains a chapter on the principles and significance of vapor proofing. It includes a chart to determine the minimum thickness of insulation to prevent condensation on cold surfaces. For a copy, write to the institute at 441 Lexington Ave., New York 17, N. Y.

TORCH BRAZING ALUMINUM—A 12-page article on Torch Brazing Aluminum that was published by The Welding Engineer is now available as a 12-page reprint. For a copy, write to Air Reduction Sales Co., 60 E. 42nd St., New York 17, N. Y.



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LONG life, increased efficiency and freedom from maintenance costs are three sound reasons why *any type of system is a better system* with Revere Copper and Brass.

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STOKER MANUAL—The second edition of the SMA Technical Manual of the Underfeed Stoker Industry has just been published. The first edition of the manual was published in 1934 and nearly 25,000 copies were distributed. Standards and recommended practices in the manual represent the cumulative experience of manufacturer members of the national stoker organization. Paper bound, there are thumb tab spacers to mark the eight sections of the 66 pages. Price, $1. Write to Lloyd L. Connell, Technical Director, 307 N. Michigan Ave., Chicago 1, Ill.

CARBON TETRACHLORIDE—The characteristics of carbon tetrachloride and the hazards resulting from its industrial use are presented in No. 9 of the series issued by the U. S. Division of Labor Standards on Controlling Chemical Hazards. Safe handling methods are given and recommendations are made as regards engineering controls, ventilation and safe practices. For a copy of this 20-page booklet write to Division of Labor Standards, U. S. Department of Labor, Washington 25, D. C.

WATER HEATER INSTALLATION MANUAL—The first section of a comprehensive appliance installation manual, that covers installation practices used with electric water heaters throughout the country, has been issued by the Edison Electric Institute. All installations covered in the manual use the standard two-element water heater known as the NEMA standard. For the manual, 50 cents a copy, write to Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y.

CANDY MANUFACTURES—The newest in the series of application data sections issued by the American Society of Refrigerating Engineers is on Air Conditioning in Candy Manufacture by H. C. Hoffman, Carrier Corp. The 4-page sections covers cooling tunnels, cold rooms, hot rooms, revolving coating kettles, miscellaneous operations and methods of supplying refrigeration. Priced at 20 cents a copy, it may be obtained from the society at 40 W. 40th St., New York 18, N. Y.

TRANSIENT HEAT CONDUCTION PROBLEMS — G. A. Hawkins, Professor of Heat Transfer, Westinghouse Research Engineering Experiment Station and J. T. Agnew, formerly Assistant Professor of Mechanical Engineering, both of Purdue University, are the authors of The Solution of Transient Heat Conduction Problems by Finite Differences, which is issued as Research Series No. 98 of the Engineering Experiment Station of the college. The purpose of this bulletin is to bring the treatments for slabs, cylinders, and spheres together under one cover. The first application of finite differences to the solution of unsteady heat conduction problems to cylinders and spheres was made by two French engineers. The analytical methods upon which each specific solution is based are discussed in detail. For a copy write to the Engineering Experiment Station, Purdue University, Lafayette, Ind.

OIL BURNER AND OIL STORAGE STANDARDS—A revised edition of Oil Burner and Oil Storage Tank Installation Standards has been issued by the Oil-Heat Institute of America to encourage better Installations. Standards apply to oil-burning equipment of all kinds installed in warm air furnaces, hot water and steam boilers, and miscellaneous industrial equipment. For copies, 10 cents each, write to the Institute at 6 E. 39th St., New York 16, N. Y.

FLUID FLOW IN PIPES — In this book of 30 typewritten pages, Clifford H. McClain has assembled information on the formulas, physical properties and the dimensions of fluid flow in pipes. It is an abridged edition of the author's Fluid Flow in Pipes and its Dimensional Analysis, and is intended for engineers who may encounter only an occasional problem having to do with fluid flow in pipes. It is intended to help the engineer determine whether he has expressed the various physical quantities in terms of consistent dimensional units. The accuracy of all calculations hinges upon the consistency of the dimensional relations used. Illustrative problems are included in the text. Price, $1. Published by the author, Clifford H. McClain, 21 W. Wilmot Ave., Havertown, Pa.

PHENOL.—No. 8 in a series of pamphlets on Controlling Chemical Hazards, covers accidental burns or poisoning that may result from improper handling of phenol. A two-page table covers the characteristics of the material. Because of the highly toxic properties of phenol, maintenance of safe working conditions is recommended, plus adequate ventilation. Free copies of pamphlet are available from the Division of Labor Standards, U. S. Dept. of Labor, Washington 25, D. C.

COST OF WELDING PIPE—The chapter on Estimating the Cost of Welding Pipe has been preprinted from the second edition of Standard Manual of Pipe Welding. Included in the 12-page booklet are tables and charts to help the contractor arrive at welding costs by the oxy-acetylene and metallic arc welding processes. Published by Heating, Piping and Air Conditioning Contractors National Association, 1250 Avenue of the Americas, New York 20, N. Y.

TESTING AND RATING CODE—The fourth edition of the I-B-R testing and rating code for low pressure cast iron heating boilers contains 75 pages of information bearing on a reliable and uniform procedure for measuring the performance of such boilers. The code is divided into four parts and covers rating of boilers, testing of hand fired boilers, testing of oil fired boilers, and procedure for obtaining I-B-R ratings. The code is followed by the Institute of Boiler and Radiator Manufacturers, the members of which produce cast iron boilers, cast iron radiators and convectors. For a copy, $1 each, write to the Institute of Boiler and Radiator Manufacturers, 60 E. 42nd St., New York 17, N. Y.

How to Sell Boilers, in Two Easy Lessons

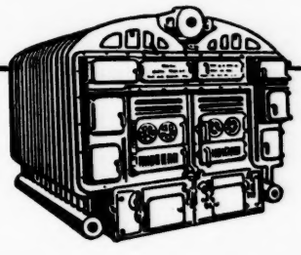
The story of radiant heating is presented colorfully and convincingly in these two new booklets, aimed to help you sell more hot water and steam heating equipment . . . and to give home planners *all* the facts about comfort heating.

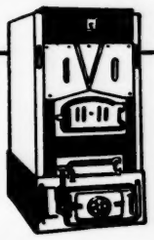
You can assure yourself that all the home planners in your community are prospects for *your* services by sending them copies of these booklets under your own name. So take advantage of this unique service *now*.

—•—

1. *Enjoy Better Living* is sponsored by The Institute of Boiler and Radiator Manufacturers through a national advertising campaign. Order your copies from the Institute at 60 East 42nd Street, New York City, Dept. SS.

2. 40 *Facts About Modern Radiant Heating* is a non-technical, easy-to-read H. B. Smith booklet featuring the outstanding advantages of radiant heating in *all* its forms. It, too, is being advertised nationally. Write to the H. B. Smith Co., Inc. for copies.





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NEWS OF THE MONTH

AIR CONDITIONING

and commercial refrigeration equipment shipments up 26% in first quarter of this year.

Shipments of components and accessories for air conditioning and commercial refrigeration equipment were valued at $46.4 million during the first quarter of 1947, according to the Bureau of the Census, Department of Commerce. The first quarter 1947 shipments set a new postwar peak, representing an increase of 26% over the fourth quarter volume of $36.9 million, and continued the steady upward trend of previous quarters.

All major classes of components and accessories and complete air conditioning equipment continued to increase. The major items increased as follows: Condensing units, 19%, from $19.1 million in the fourth quarter to $22.6 million in the first quarter; compressors and compressor units, 78%, from $4.7 million to $8.3 million; centrifugal refrigeration machines, 7%, from $1.7 million to $1.8 million; heat exchanger equipment, 20%, from $11.4 million to $13.7 million; and self-contained air conditioning units; 43%; from $6.4 million to $9.2 million.

Air Conditioning Equipment and Components and Accessories for Air Conditioning and Commercial Refrigeration Equipment: Summary of Shipments by Major Class of Product. First Quarter 1947 and Fourth Quarter 1946

Product	First Q.—1947		Fourth Q.—1946	
	Number	Value Dollars	Number	Value Dollars
TOTAL	.....	46,425,941	.....	36,870,171
Condensing units	312,254	22,590,275	269,136	19,062,983
Ammonia refrigerants	332	389,166	317	393,636
Refrigerants except ammonia	311,922	22,201,109	268,819	18,669,347
Air cooled	300,255	17,602,325	253,896	13,448,971
Open type	129,653	11,554,429	n.a.	n.a.
Hermetic type	170,602	6,047,896	n.a.	n.a.
Water cooled	11,667	4,598,784	14,923	5,220,376
Compressors and compressor units	147,832	8,320,720	81,117	4,678,259
Ammonia refrigerants	783	1,996,870	625	1,371,101
Refrigerants except ammonia	147,049	6.323,850	80,492	3,307,158
Centrifugal refrigeration machines	84	1,837,409	78	1,724,066
Heat exchanger equipment	.....	13,677,537	.....	11,404,863
Evaporative condensers	1,627	1,784,052	1,453	1,391,866
Unit coolers	48,385	5,608,699	55,084	5,506,059
Air conditioning	3,929	1,474,532	4,660	1,215,739
Refrigeration	44,456	4,134,167	50,424	4,290,320
Other heat exchanger equipment[1]	.....	6,284,786	.....	4,506,938
Self-contained air conditioning units	18,749	9,168,212	14,365	6,390,796
Room type	11,656	2,691,627	9,510	2,119,615
Other than room type	7,093	6,476,585	4,855	4,271,181
Ice making machines	1,934	1,268,742	n.a.	n.a.

n.a. Not available

[1]Includes condensers and liquid coolers, shell and tube and shell and coil types, as well as fin coils (heating and cooling) and plate type evaporators.

• **SCOPE OF SURVEY.**—The release covering the survey (Facts for Industry, Series M52A-1-7) is based on reports submitted by 72 manufacturers of components and accessories and complete air conditioning equipment. Estimates were made for a few companies, representing only a small portion of the total industry, that did not submit their reports in time to be tabulated. The reports included in the release are believed to represent substantially all component manufacturers and air conditioning equipment producers.

The shipment statistics included in the report apply to equipment actually billed and shipped. These figures are equivalent to completed sales. Complete units delivered on consignment or shipped to a branch warehouse for stocks are not included until such time as they are actually sold. The dollar values shown are the manufacturers' net billing prices, f.o.b. factory. The data for some types of air conditioning and refrigeration equipment have been combined in the tables of this report in order to avoid disclosing the operations of individual companies.

The tables in this report present information on manufacturers' shipments of air conditioning equipment, and components and accessories for air conditioning and commercial refrigeration equipment. One table, a condensation of which is presented here, presents summary data on shipments for the fourth quarter of 1946 and first quarter of 1947. A second table, shown in the release cited, covers detailed information on these products for the first quarter.

BUILDING TECHNOLOGY DIVISION

established at National Bureau of Standards to unify attack on problems related to structures.

A new Division of Building Technology has been established at the National Bureau of Standards, according to an announcement by Dr. E. U. Condon, director of the bureau.

• **FORMATIVE.**—By no means a finished organization, the new division is made up of a number of sections and parts of sections which have come to be exclusively concerned with various phases of building technology. It is felt that a unified attack on building problems can be more effectively achieved by concentrating these sections in a single division, though they cut across the classical lines of physics, chemistry, and engineering.

The nucleus of the new division consists of five sections: structural engineering; fire protection;

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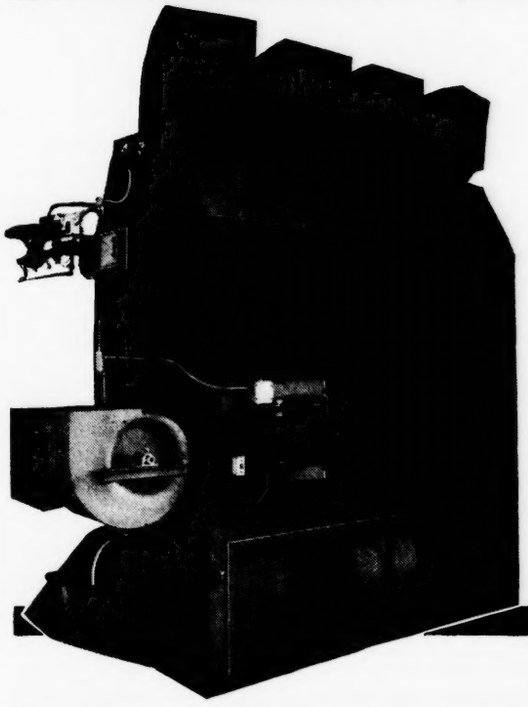

1. A complete factory heating unit.
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For detailed information, write for Bulletin 801-A.

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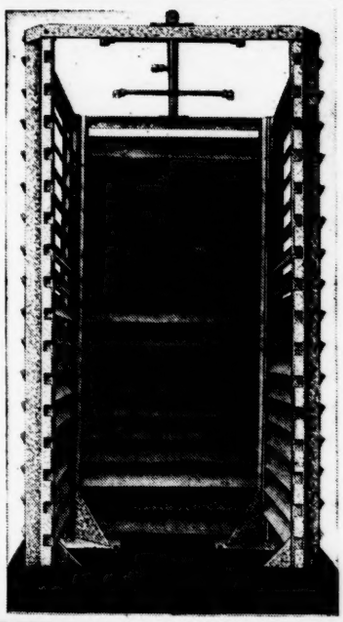
BIG or small . . . there's a Binks atmospheric cooling tower to fit your particular needs



A Binks Type "S" Cooling Tower is ideal where there is natural air movement. This improved model is widely used for cooling condenser circulating water from refrigeration, and air conditioning compressors . . . for cooling all types of water-jacketed engines . . . for cooling water and other liquids from manufacturing processes.

Standard Binks Type "S" Atmospheric Spray Cooling Towers are built in 30 sizes with capacities from 10 to 1200 G.P.M. This wide range of sizes enables you to buy the best in cooling towers for any size installation without the added expense of a custom built tower.

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A data-packed booklet about Binks "S" Cooling towers, their specifications, capacities and much other helpful information.

THERE IS A BINKS COOLING TOWER FOR EVERY WATER COOLING JOB

BINKS TYPE "S" 30 STANDARD SIZES | **Binks MANUFACTURING COMPANY** 3114-40 CARROLL AVE., CHICAGO 12, ILLINOIS • OFFICES IN ALL IMPORTANT CITIES

heating, ventilating and air conditioning; exterior and interior coverings; and codes and specifications. The structural engineering section will deal with the strength, stability, and stiffness of buildings and the structural elements of buildings. The fire protection section will continue its work on fire resistance of building construction, the fire hazard of building contents, and fire detecting and extinguishing equipment. Heating, ventilating and air conditioning systems and heat transfer through materials and constructions will be the responsibility of the heating and air conditioning sections. The exterior and interior coverings section will handle roofing and waterproofing; floor, wall and ceiling finishes for buildings; and in general the chemical and physical properties of bitumens. The codes and specifications section will carry on work formerly performed in another division on building, plumbing and safety codes and standards, building fixtures and service equipment and construction and maintenance practices.

• **SCOPE.**—As research techniques crystallize, work which is continuing elsewhere in the Bureau, such as acoustics for example, may be transferred to the Building Technology Division. Fundamental research on physical properties and constants will be conducted by the appropriate Bureau units at the request of the new division.

Research will be limited to the three fields of physics, chemistry and engineering. Broader subjects, such as planning for housing developments, choice of sites, or aesthetic matters, do not fall within the scope of the Bureau's activities. However, cooperative work on the development of recommended code requirements and practices will be continued in close association with laboratory research so that the full benefit of such research will be available promptly for the use of national standardizing bodies. One of the major jobs for this year is the preparation for publication of much already-accumulated research data.

FLOOR SLAB TESTS

set up at University of Illinois to determine economical construction techniques.

What is the most economical way to build a dry, comfortably warm, concrete-slab floor for a basementless house? To answer that question, the University of Illinois will do research on 10 different types of concrete-slab floors. These floors will be tested for temperature variation and moisture conditions.

• **JOINT EFFORT.**—The research project was arranged by the Small Homes Council of the University, and will be carried on in cooperation with United States Department of Commerce's Industrial Research and Development Division, Office of Technical Services. The study will be made at the Small Homes Research Center on the campus by the University's mechanical engineering department, which has done research in home heating for more than 30 years.

• **SET-UP.**—For purposes of the experiment, a one-story, windowless building, 75 ft long and 16 ft wide, will be built. This will be divided into a series of small cells or rooms, each of which will have a different type of concrete floor. Some of the floors will be laid directly on the ground without any insulation; some will be "floating foundations" (like sidewalks); others will have gravel, cinder, or other types of insulating materials under the concrete.

Each room will be insulated from adjoining test cells; each will be heated electrically; and each will house instruments for the measurement of floor temperature and moisture conditions. An instrument room at one end of the test structure will connect with the 10 test rooms by means of a narrow corridor.

By the use of 360 thermocouples, electrical units for reporting temperatures, research men will be able accurately to measure temperatures below the floor and at various points of the outside foundation walls without entering the individual testrooms. Seven miles of electrical wiring will be installed in the test structure to connect these thermocouples to the instrument panel.

• **TESTS.**—Testing of moisture conditions will begin as soon as the building, which now is under construction, is completed. Temperature tests will be started in the fall and will be carried through one complete heating season.

The test structure is being built under the supervision of Professor James T. Lendrum, associate coordinator of the Small Homes Council. Harlan D. Bareither, assistant in mechanical engineering, will make the study under the direction of Professor S. Konzo.

HEAT MEASUREMENT

advanced by new flow calorimeter and thermometric calibrator.

Two developments in the measurement and standardization of heat recording emerged from the Bureau of Standards last month. A new flow calorimeter for more accurate measurements of the specific heats of gases has been developed by R. B. Scott, and a new thermometric callibrator utilizing the freezing point of benzoic acid as a fixed temperature has been developed and made available to industrial and other laboratories by the Bureau.

• **CALORIMETER.**—The gas calorimeter was constructed in connection with an investigation of the thermodynamic properties of materials involved in the production of synthetic rubber and related substances. The greater precision of the new instrument

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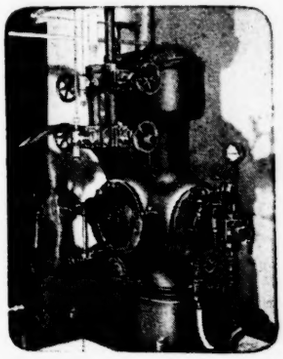
Frick Freon-12 Compressors Air Condition an Office Building

Whether You Need Ammonia or Freon-12 Equipment, You Get What You Want with



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FRICK Refrigeration

As builders of both ammonia and low-pressure systems, we are in an unbiased position in filling your requirements.

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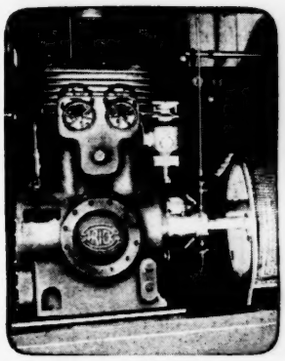

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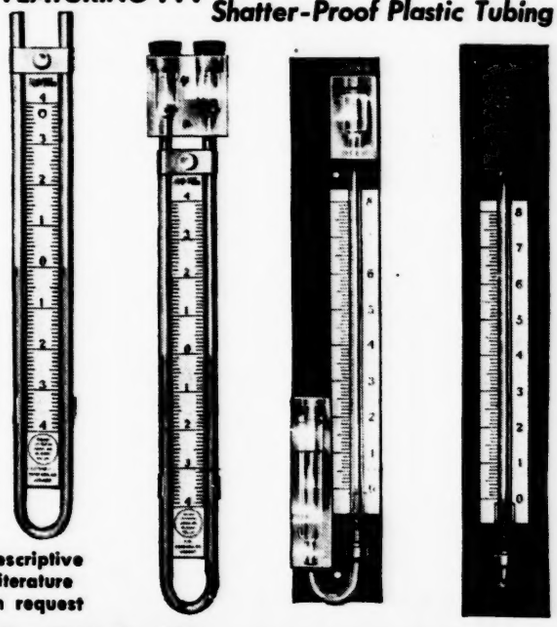
FEATURING . . . Over Pressure Safety Trap
Shatter-Proof Plastic Tubing



Descriptive literature on request

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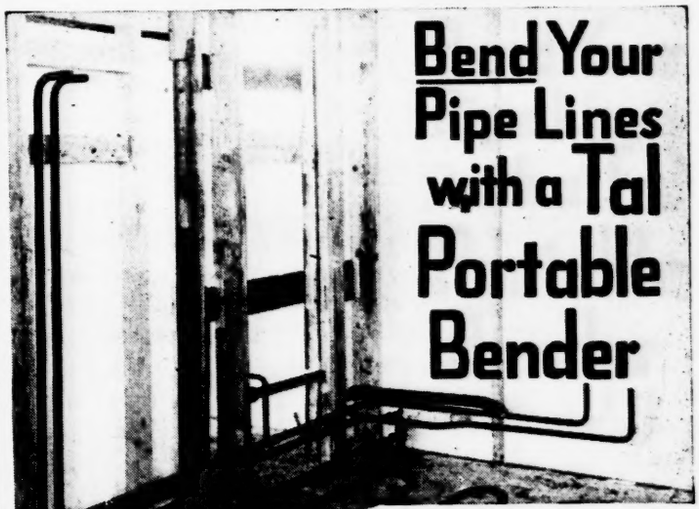

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Bending is both the fastest and the easiest way of handling pipe . . . and you gain even more time with a Tal portable bender, the simplest, fastest-working machine. Anyone can handle a Tal—even first day apprentices can make perfect, true bends, cold, to any radius up to 180° in one single operation. A great on-the-job tool, this portable machine eliminates the use of bends and fittings, reduces up to 80% the need for welds, handles all wrought iron or steel pipe from ⅜" to 3". No wonder thousands are already being used by alert contractors everywhere. Write for illustrated data bulletin. Dept. H.V.-9.

TAL Prestal Bender, Inc. Milwaukee 2, Wis.

is chiefly the result of almost complete elimination of heat leaks by various features of design.

The heat capacity per unit volume of a gas is so low that small accidental heat leaks are often comparable in size to the heat used in actually raising the temperature of the gas a measured amount. Reduction of the ratio of heat loss or gain to heat input is thus one of the chief problems in gas calorimetry. In the calorimeter constructed at the Bureau, this is accomplished by causing the gas to flow continuously at a uniform rate through an insulated chamber in which it is heated electrically. The heat capacity is then calculated from the heat input, the temperature rise of the base and the rate of flow. In the new apparatus, special precautions have reduced heat leaks to such an extent that correction for them is unnecessary, the number of necessary observations is reduced, and results now obtained are more trustworthy than with other methods.

The entire calorimeter is immersed in a constant-temperature bath. The gas, specific heat of which is to be measured, enters the system through a copper helix, in which it is brought to the temperature of the bath. It then flows into the calorimeter proper, where it traverses a labyrinth surrounding a constantan heater, and leaves the calorimeter through a throttle valve. The temperature rise within the calorimeter is determined by appropriately located thermocouple junctions.

A uniform rate of gas flow is obtained by maintaining a constant pressure on the inlet side of the calorimeter and a constant lower pressure at the outlet. Adjustment of the throttle valve in the outlet tube then provides the desired rate of flow, which is determined by weighing the gas collected in a condensing reservoir within a given time.

• **BENZOIC ACID CELL.** — The development of the benzoic acid cell for thermometric standardization affords a means of calibrating resistance thermometers and thermocouples at a temperature near 212F, more rapidly and conveniently and, under certain conditions, more accurately than is possible with the boiling point of water. Benzoic acid, which is especially purified for the purpose, is contained in a cylindrical chamber about 12 in. long and 2 in. in diameter, provided with a thermometer well. To use the cell, it is heated in an oven until the acid has melted and reached a temperature a few degrees above its freezing point. The cell is then shaken until the liquid begins to freeze, forming a mush of fine crystals. The cell is then put in a flask to retard the rate of freezing and the instrument to be calibrated is placed in the well. Observations of resistance are made for a period of one or two hours. After the first 30 minutes the temperature of the cell is constant within 0.001C for an hour or longer and is reproduced in repeated freezers within the measurement range of 0.002C. Temperature provided by the cell is virtually the triple point of benzoic acid (122.362C). Certified cells may be obtained from the National Bureau of Standards for $100 each.

MINE GASIFICATION

at Gorgas proves successful beyond expectations.

Economic studies to assess cost factors and gauge the industrial significance of burning unmined coal to produce gas were recommended to the Bureau of Mines after scientists representing industry, government, the armed services, and educational institutions were told that the results of a joint experiment by the Alabama Power Company and the Bureau at Gorgas, Ala., had surpassed expectations.

"What we accomplished exceeded what we thought we would accomplish," Milton H. Fies, manager of coal operations for the utility company, stated in summarizing observations made at the conclusion of this underground coal gasification test.

• **POSSIBILITIES.**—If proved practical—and further research will be necessary, speakers emphasized—underground coal gasification offers revolutionary possibilities. It may provide a cheaper fuel for electric power generated at the mine and distributed for industrial and domestic use. It may simplify transportation of fuel energy, sending it to the consumer as electrical power instead of bulk coal. It may rid our cities of the smoke and soot nuisance. It may tap unused natural resources, vast beds of impure coal and others too thin to mine.

There are other potential uses for the hydrogen and carbon monoxide gases sought in burning unmined coal, the conferees agreed. They offer a source of raw materials for the manufacture of synthetic liquid fuels and the hydrocarbons needed for the production of many chemicals.

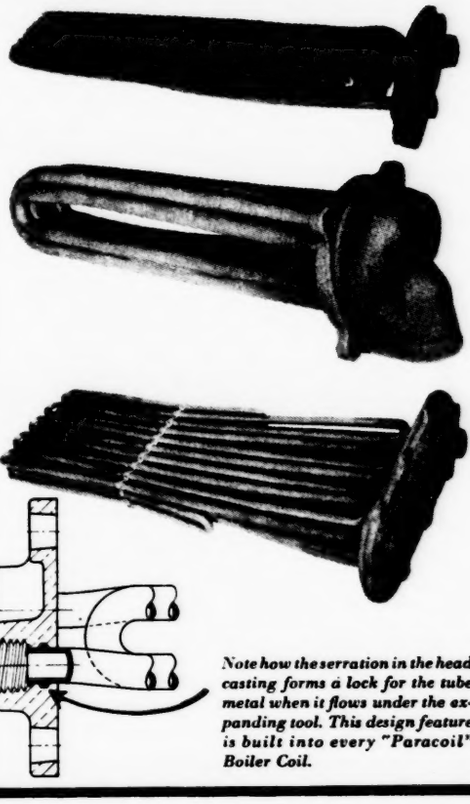
• **THE EXPERIMENT.**—At Gorgas, where a block of coal was isolated and set afire with incendiary bombs under controlled conditions, Mr. Fies and Bureau of Mines engineers said that the coal was burned out clean without wastage. The shale roof, made plastic by intense heat exceeding 2,300 degrees Fahrenheit, expanded and folded down gradually to occupy the space left by the consumed coal. Air needed for combustion continued to flow, however, between the rock-coal interface. The roof-rock or shale was particularly favorable for underground gasification, swelling to two or three times its original volume and still maintaining sufficient strength to hold up the overburden and prevent subsidence.

At a conference held in Bureau of Mines offices in Washington, J. L. Elder, Bureau chemical engineer, stated that during the course of the 50-day project, 63 air-blast "runs" were made averaging 14 hours in length. To feed the flames at the base of a U-shaped tunnel, a blower pushed various concentrations of air and oxygen in at one portal while the gases were being trapped for careful analysis as they emerged at the other. Live steam blasts also were introduced alternately with air, for steam combines with carbon at high temperatures to produce the desired carbon monoxide and hydrogen. Gas qualities obtained were not as good as is deemed possible, in part because the

Paracoil Submerged Boiler Coils

★ ★ ★ ★ ★ ★ ★ ★ ★ ★

for HOME and INDUSTRY



Note how the serration in the head casting forms a lock for the tube metal when it flows under the expanding tool. This design feature is built into every "Paracoil" Boiler Coil.

"Paracoil" has been building dependable boiler coils since 1915 for both home and industry. Here are a few of the varied types of instantaneous tankless water coils we are now fabricating for domestic residence boilers.

All head castings have SERRATED TUBE CONNECTIONS—another "Paracoil" design feature! You are doubly protected against leaks with a "Paracoil" Boiler Coil!

"Paracoil" Boiler Coils are designed for use with or without a storage tank. The larger industrial models are built with integrally cast water chambers and tube sheets to any desired capacity.

"Paracoil" manufactures many types of heating and ventilating accessories—all distributed through franchised agents. Some lucrative territories are still available. If interested, write our Elizabeth office for details.

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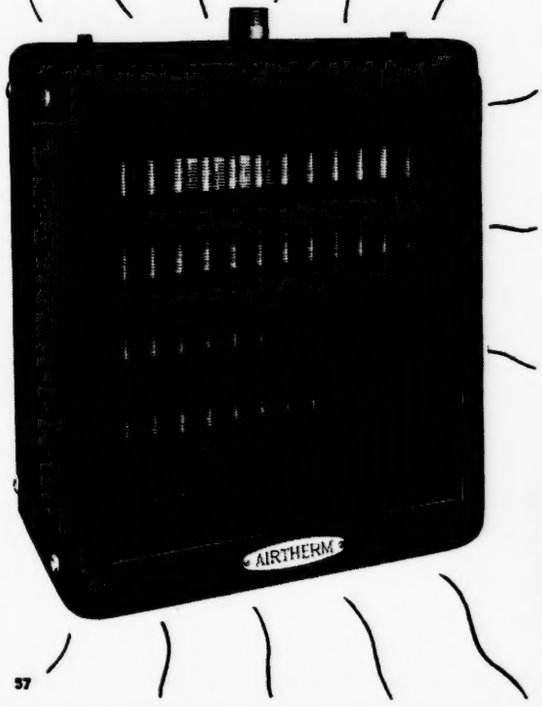

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AIRTHERM STEAM UNIT HEATERS

PROVIDE HEAT WHERE YOU WANT IT— WHEN YOU WANT IT

Airtherm Steam Unit Heaters can be individually controlled, providing heat only when you need it, and where you want it—thus reflecting a saving in your fuel costs. They move warm air quickly over wide areas and into remote corners, giving uniform heat throughout the plant.

There's an Airtherm Steam Unit Heater for every heating application. Write for Bulletin 1206 giving detailed information and range of available sizes.

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AIRTHERM MANUFACTURING COMPANY

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light overburden and leakages prevented using air under high enough pressures. However, the gas was used for a small field boiler. Higher pressures, temperatures, and gas velocities, insuring quick removal of the gases before contaminating reactions occurred, would produce better quality gases, Elder concluded.

• **AFTERMATH.**—Discussing the excavating and mining conducted after the fire was extinguished to learn what had occurred underground, James J. Dowd, Bureau mining engineer, said that temperatures still exceeded 200 degrees even after steam was forced through the mine for five days and water for eight days in an effort to cool it. Workers were able to remain in the mine only for short periods, and once the still hot coal again burst into flame.

In driving adits and a bulldozer trench into the mine after the fire was extinguished, the workers in turn encountered intact coal, slightly carbonized coal, coke, fused clay from bags which had been stacked along the tunnel to confine the flames, and then the folded and expanded roof material over a thin bed of ashes where the coal had been burned out completely. A problem remaining to be solved is a practical method for confining the flames to the desired area so that they will not encroach upon neighboring properties in any given coal bed, the conferees agreed. The clay bags proved inadequate.

• **FUTURE.**—Dr. L. C. McCabe, chief of the Bureau's coal division, discussed briefly his recent conferences on underground coal gasification with Belgian scientists at Brussels. The Belgians, he said, were unwilling to release much information on their gasification experiments until patents can be obtained. However, they held that roof conditions and the use of a pulsating air current are keys to success, he said.

Outlining a possible future course for Bureau research, Dr. W. C. Schroeder, chief of the Bureau's Office of Synthetic Liquid Fuels, said that underground coal gasification, unlike most scientific problems, cannot be broken down into component parts and pursued in the laboratory. It must be done in the field on a fairly large scale, he stated, adding that any future experiment should approach a commercial-size operation encompassing perhaps 200 to 300 acres of coal land. As one method of attack to minimize initial mining costs, he proposed a development plan involving the drilling of boreholes from the surface and the burning of the coal bed between them.

• **HISTORY.**—Dr. A. C. Fieldner, chief of the Bureau's Fuels and Explosives Branch, was chairman of the meeting. In the absence of the Bureau's Director, Dr. R. R. Sayers, who was unable to be present, Dr. Fieldner reviewed briefly the history of underground coal gasification in which the Russians have pioneered. It was an Englishman, Sir William Siemens, however, who first suggested in 1868 the gasification of slack and waste coal in the mine. In 1938, following five years of small scale experimentations, the Russians decided to build and put into operation a series of industrial stations for underground gasification in the Donetz coal basin, the Lower Moscow coal basin, and eastern U.S.S.R., making use of the gas for power, chemical works, and domestic purposes. The largest station, that in the Donetz basin, was planned to produce 14 million cubic feet of gas per hour, equivalent to about a half million tons of coal per year, but little is known about it other than that it is reported to have been operated successfully. The Bureau of Mines has made several attempts to arrange for an American engineering team to study these operations in Russia but has not been successful to date.

CONSTRUCTION ACTIVITY

analyzed by states in Commerce Department report on first half of 1947.

A breakdown by States of estimated new construction activity during the first and second quarters of 1947 is presented in the August Construction and Construction Materials Industry Report of the Department of Commerce.

• **TABULATED.** — The first of a series of three tabulations prepared by the Construction Division, Office of Domestic Commerce, gives a breakdown of total new construction for each quarter. For the first quarter, new construction put in place totaled $2,460 million and for the second quarter $2,888 million. Privately financed construction amounted to $1,948 million in the first quarter and $2,181 million in the second quarter.

California led all States with a total of $384 million in the first quarter and $414 million in the second quarter. New York was second with a total of $187 million in the first quarter and $202 million in the second. Third in volume was Texas with a total of $176 million in the first and $218 million in the second quarter.

A second table gives a breakdown by States of private construction covering residential, non-residential, farm and public utility building. For the first quarter residential building is estimated at $869 million and for the second quarter at $1,080 million, with California out front and Texas second.

Private non-residential construction for the first quarter is estimated at $782 million and for the second quarter at $733 million, with California again leading in both quarters. New York occupied second place in the first quarter and was replaced by Texas in the second quarter. Iowa led the States in farm construction in both quarters and California was ahead in privately financed public utility construction in both quarters.

Another table gives a State breakdown of new public construction by non-residential building, highway construction, sewer and water construction and "all other" public construction. New York led in public non-residential building in both quarters and also in "all

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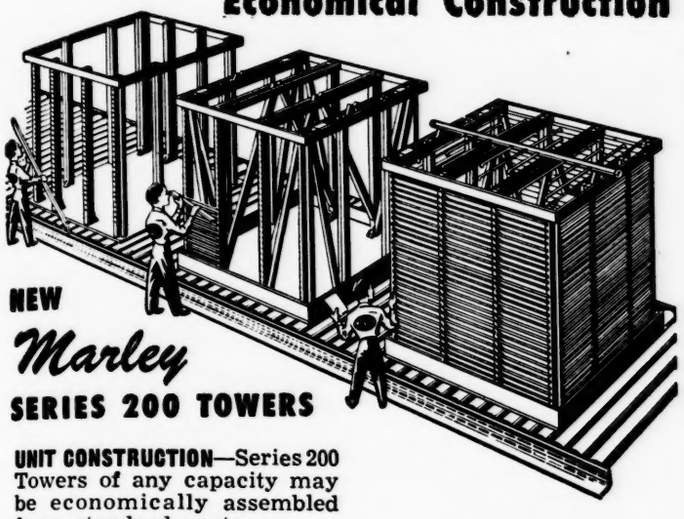

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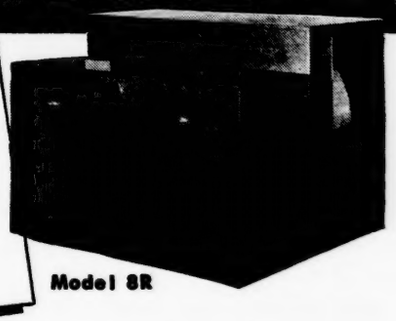

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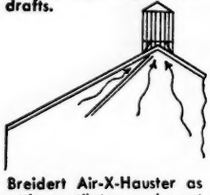

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other" public construction. Texas was out front in highway construction in both quarters and California in sewer and water construction.

• **HEATING EQUIPMENT.** — June production of cast iron radiation (including cast iron convectors) was 4,472 thousand square feet, a decrease of 10% from May. Production in the first half of this year totaled 27,925 thousand square feet, an increase of 78% over the same period in 1946.

PILOT PLANT

contract is let for coal gasification project. Blaw-Knox to begin construction this year.

The Research and Development Division of Pittsburgh Consolidation Coal Co. has awarded the contract for design and construction of its coal gasification pilot plant to Chemical Plants Division of Blaw-Knox Company.

• **COOPERATIVE.** — This pilot plant is a cooperative project sponsored jointly by Standard Oil Development Company and Pittsburgh Consolidation Coal Company. The purpose of the plant is to ascertain whether a practical and commercial process can be found for making synthesis gas, a first step in producing synthetic fuel from coal (H&V:4:47:p.114).

Present estimates indicate the cost of the pilot plant will be in excess of $500,000. It will be located at Library, near the coal company's research center.

• **CONTINUOUS.**—The pilot plant will be a completely integrated and continuous processing unit, the heart of which will be a synthesis gas generator, a cylindrical column supported by a steel structure about 80 feet high. The pilot plant will generate approximately 1,000,000 cubic feet of synthesis gas per day. According to Blaw-Knox, construction work is expected to begin later this year.

NEWS BRIEFS

• Construction of a $450,000 *anthracite laboratory* at Schuylkill Haven, Pa., has been authorized by Congress and will be operated with a staff of 30 by the Bureau of Mines on a $175,000 annual budget. Land will be donated by the Philadelphia and Reading Coal and Iron Co. Objective will be improvement in anthracite mining methods.

• Plans for a 500-mile, $22 million, *petroleum pipeline* from Cushing, Okla., to Wood River and Salem, Ill., have been announced by joint owners, Shell Pipe Line Corp., and The Texas Pipe Line Co. This line is an extension of one already under construction from West Texas-New Mexico to Cushing and will have a capacity of 150,000 barrels per day.

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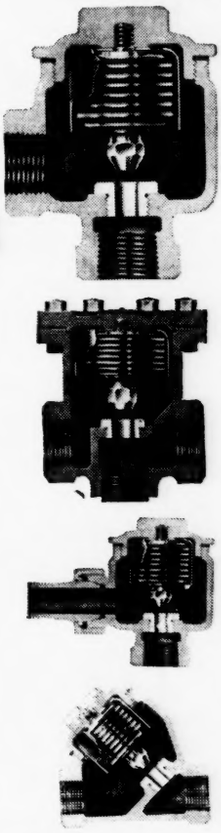

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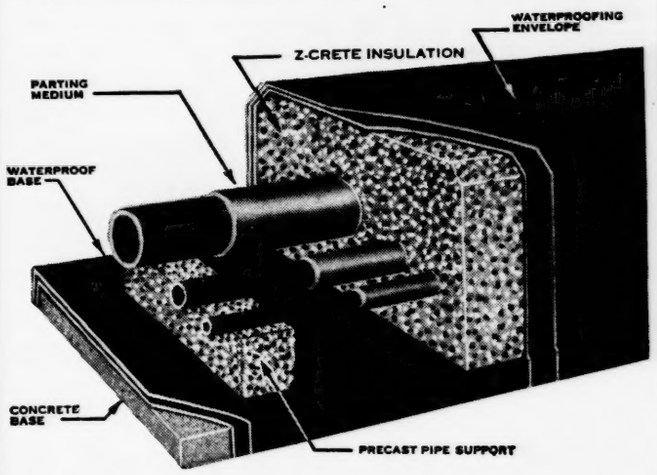

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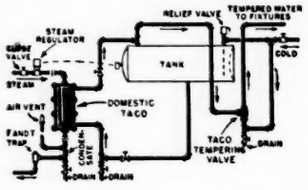

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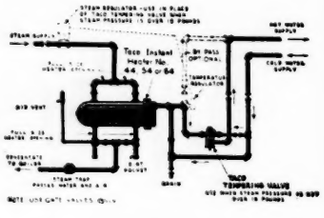

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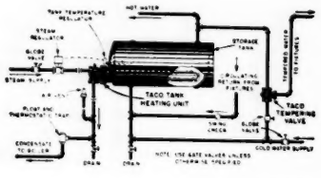

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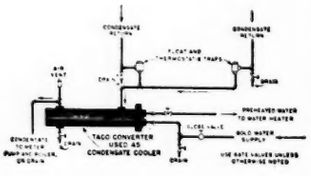

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Webster system for convection heating is described as concealed, lightweight equipment in a new 16-page, 2-color booklet. Sizing, design, and installation data are presented for five types of concealed installation. Rated capacities of heating elements are tabulated.—*Warren Webster & Co., Camden, N. J.* **350**

Replacable Air Filters

The application of replacable type air filters for ventilating and air-conditioning systems is explained in an eight-page booklet. Descriptions and illustrations of each type filter are given, along with instructions for maintenance and detailed engineering and installation data.—*American Air Filter Co., Inc., 215 Central Ave., Louisville 8, Ky.* **351**

Refrigeration Pipe Coils

Engineered pipe coils for refrigeration work are described in a 6-page bulletin, No. 156-C. These coils are for use in cold storage plants and wherever large refrigeration capacity is required.—*Frick Company, Waynesboro, Pa.* **352**

Ventilators

An illustrated 3-color booklet tells of Breidert Air-X-Hauster results in wind tunnel tests and in actual use on all types of installations. Advantages gained by applying aerodynamic principles to ventilator design are fully described. — *G. C. Breidert Company, 3129 San Fernando Road, Los Angeles 41, Calif.* **353**

Humidity Control

An 8-page booklet entitled "Humidity Control is more important in your plant than you may realize," explains the principle of operation and details of application of the Kathabar system of selective humidity control for industrial processing applications. Flexibility of the operation is illustrated by a chart giving the various temperature-humidity conditions available from the system, as it might be applied to one large processing plant requiring different humidity conditions for processing, packaging, storing, personal comfort, etc. Numerous installations are illustrated.—*Surface Combustion Corp., Toledo 1, Ohio.* **354**

Oil Filters

Type "O" Air-Maze oil filters for full flow filtration of lubricating, hydraulic, fuel oils is the subject of a 4-page folder, OFC-847.—*Air-Maze Corp., Cleveland 5, Ohio.* **355**

Duct Furnace

A gas-fired duct furnace available in five capacities is introduced by a four-page two-color folder. The duct furnace features a principle of controlled heat referred to by the manufacturer as duo stage temperature modulation. This feature automatically reduces total heat delivery with undiminished air delivery.—*Pacific Heater Division, Naco Mfg. Co., Box 310, Huntington Park, Calif.* **356**

Building and Plumbing Products

A new service catalog has been published by the J. A. Zurn Mfg. Company that presents their line of building, plumbing, drainage products numbering over 250 items. Drains, interceptors, traps, wall fixture carriers, wall closet fittings, hydrants and street washers and swimming pool equipment are among the product classifications described. This 76-page booklet contains complete tables of sizes, weights, dimensions, and prices for every item, including engineering drawings and illustrations of every item. Service Catalog No. 47-1.—*J. A. Zurn Mfg. Co., Plumbing Division, Erie, Pa.* **357**

Welding and Cutting Equipment

A full color, 20-page catalog describes and illustrates the Victor line of oxy-acetylene welding and cutting equipment and accessories. Equipment is assembled in sales packages for different applications and requirements. Safety regulators and hand cutting torches are shown, with price list and size data.—*Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.* **358**

Refrigeration Control

A 12-page, 2-color catalog, Bulletin 2652, features load-carrying, 2-pole Series 270 refrigeration and air conditioning controls. Information includes a listing of standard types available, specifications, dimensions and typical wiring diagrams illustrating the application versatility of the 2-pole construction. — *Penn Electric Switch Co., Goshen, Ind.* **359**

Flat Belting Data

Featuring sizing and capacity tables and other technical data, a new 12-page catalog section on "Selection and Maintenance of Rubber Transmission Belts" is a guide to the application and care of flat rubber belting. Rules for determining the horsepower, the formula for finding the arc of contact, length of open drive and crossed endless belts, correct lengths to cut belts and belt speeds are included.—*The B. F. Goodrich Co., Akron, Ohio.* **360**

Boilers and Radiators

Cast iron boilers and radiators with new prices effective August 4, are described in a four-page folder. —*Dunkirk Radiator Corp., Dunkirk, New York.* **361**

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The Kontrol Motor line of pressure regulators and diaphragm motor valves is described in a new catalog, No. 47 of over 100 pages made up in five sections covering, in addition to diaphragm valves, the company's lines of liquid level controllers, strainers, pressure reducing and regulating valves, pump governors, and such steam plant equipment as back pressure valves, atmospheric relief valves, diaphragm relief valves, oil and grease extractors, and exhaust heads.—*Kieley & Mueller, Inc., North Bergen, N. J.* **362**

Greensand Zeolite Softeners

Up-to-date data on the greensand zeolite softening process and zeolite softening equipment are presented in a new 20-page manual designated Publ. 4345. The need for water softening and the various available methods of treatment are reviewed. Applications to boiler feed, water-jacketed equipment, and processing in specific industries such as food canning, textile, laundries, and institutions are briefly described. Three pages are devoted to the chemistry of the process, including the softening, backwashing, brining, rinsing and the complete regeneration process. Complete dimensions, weights, and list prices are given in a two-page table.—*Cochrane Corp., 17th St. & Allegheny Ave., Philadelphia 32, Pa.* **363**

Worm-Feed Stokers

An 8-page bulletin illustrates and describes the Brownell line of worm-feed stokers comprising 11 sizes with capacities of 177 to 1000 lb per hr. The features especially emphasized are precision-built mechanism, 3-speed control, safety cut-out switch, automatic air-volume control, and gas repellent valve, the last said to be a positive preventive of gas blowback.—*The Brownell Company, 410 N. Findlay St., Dayton 1, Ohio.* **364**

Vapor Equalizing Valves

The Gorton system of vaporizing and equalizing existing steam heating systems, said to heat all radiators evenly on 4 to 8 ounces of vapor without piping changes, is described in Bulletin No. 115, 4 pages, 2 colors. Price list for valves and air eliminators is inserted. — *Gorton Heating Corporation, Cranford, New Jersey.* **365**

Expansion Joints

Bulletin EJ-47 describes CMH free-flexing and controlled-flexing bellows-type expansion joints for controlling expansion, vibration, and misalignment in pipe lines having pressures to 300 p.s.i. and temperatures to 900F. Free-flexing and controlled-flexing designs with copper and stainless steel corrugations are illustrated, and data are given for each type shown. Sizes range from 4 in. to 24 in. inside diameters, with single and multiple-corrugations.—*Chicago Metal Hose Corp., Expansion Joint Division, Maywood, Ill.* **366**

Paint Spray Systems

Planned systems for complete paint finishing, metal-preparation washers, paint spray booths, drying and baking ovens are described and illustrated in technical bulletin No. 501, twelve pages, two colors. The booklet outlines basic points to be considered in the planning of a complete organic finishing seasoning.—*Peters-Dalton, Inc., 17900 Ryan Rd., Detroit 12, Mich.* **367**

Control Valves

Frick electric control valves are described in a four page bulletin, No. 203-F, with sizing and price tables, illustrations, etc. These valves are described as automatic, packless valves for use as shut-off valves in either the liquid or suction lines of refrigerating plants having one, two or more evaporators to the control.—*Frick Company, Waynesboro, Pa.* **368**

Protective Coating and Lining

A new brochure on protective coating and lining for steel and other metals, illustrated, 8 pages, describes a wide range of Lithcote applications, plant and field facilities, research, and actual names of users. Reports of laboratory tests are included. These show the results of suspending Lithcoted strips of mild steel at room temperature in various solutions, such as inorganic and organic acids and compounds, also results of special tests.—*Lithgow Corp. 333 West 40th Place, Chicago 9, Ill.* **369**

Roof Ventilator Data

A tab-indexed technical bulletin, catalogued 446, presents engineering and application data covering Airjet roof ventilators and vent flue caps. Booklet includes reports of tests. — *C. R. Gelert Company. 35 N. Raymond Ave., Pasadena 1, Cal.* **370**

SEPTEMBER, 1947

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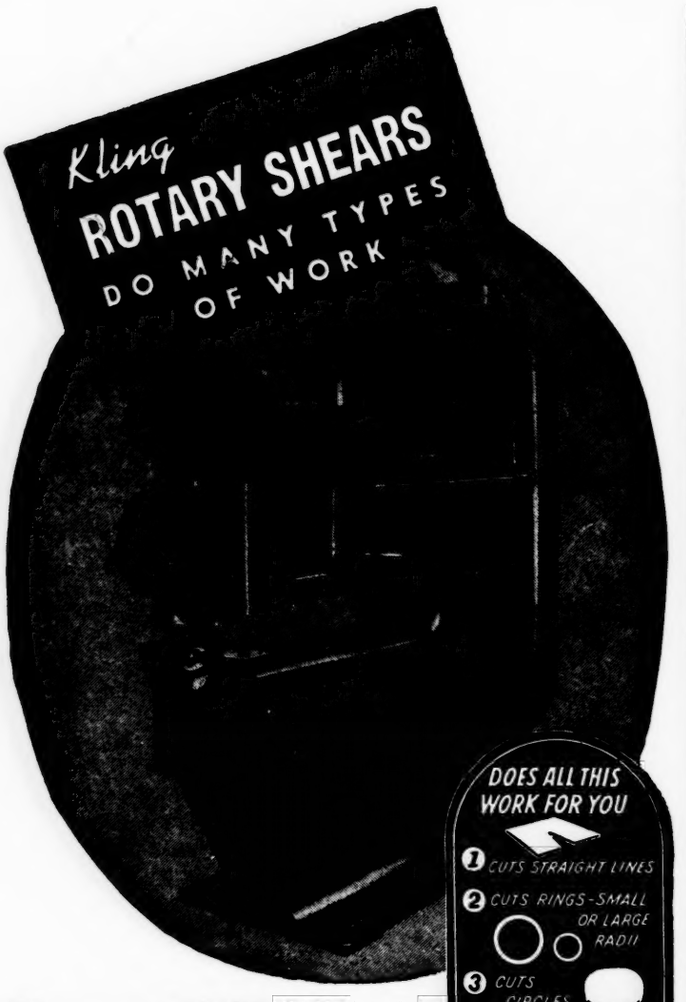

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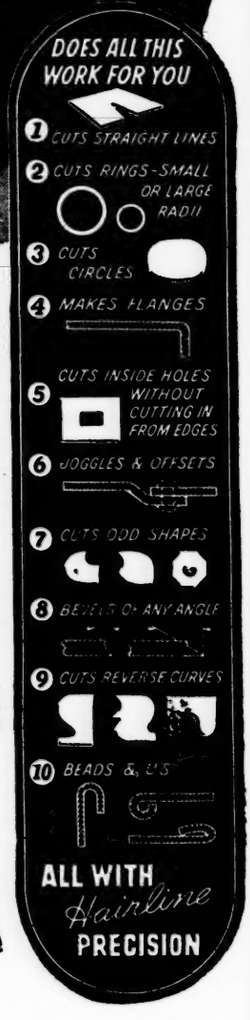
For exacting projects (see illustration at the right), no single unit of metal-working equipment does so many different things so cleanly and efficiently as does the Kling Rotary, pictured above.

In metal-working plants, automotive, aviation, home appliance, and other industries, where work of this character is being done,—this machine is held in high regard for its versatility and economy of operation.

This great usefulness is the result of half-a-hundred years of engineering experience which prospective buyers, with reason and respect, applaud.


DOES ALL THIS WORK FOR YOU
1 CUTS STRAIGHT LINES
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4 MAKES FLANGES
5 CUTS INSIDE HOLES WITHOUT CUTTING IN FROM EDGES
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7 CUTS ODD SHAPES
8 BEVELS OF ANY ANGLE
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10 BEADS & CURLS
ALL WITH Hairline PRECISION

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which will give you specific facts, and specifications. No obligation involved. Users of "heavy equipment of Kling Rotary Shears' class will receive a copy of this Bulletin promptly, on request.

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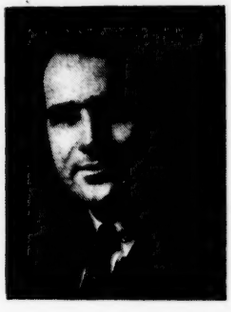
Getting Personal

R. W. Tuthill *(Welding by the Inert-Arc Process*, page 83) received his Bachelor of Science in Mechanical Engineering degree from Pratt Institute in 1941. He joined the General Electric Co. test course and was assigned to the Electric Welding Division. He left that division in 1944 to join the Navy, spending his time at Newport, R. I., designing torpedoes. He returned to the Electric Welding Division in September, 1946.

R. W. Tuthill



W. J. Campbell

W. J. Campbell, co-author of the article on welding, page 83, is a graduate of Tri-State College with a degree in mechanical engineering. He joined the General Electric Co. in 1941 as a member of the company's Electric Welding Division. Since October, 1945, he has worked on application engineering assignments. On July 1, 1947 he became G-E arc welding specialist for the southeastern district with headquarters in Atlanta, Ga.

. . Since the Last Issue

Opening of a Richmond, Va., office of the **Sturtevant Division of the Westinghouse Electric Corp.** at 218 Travelers Building, 1108 E. Main St., has been announced. **Joseph A. Hagan, Jr.,** who was a Marine captain in World War II, is manager of the new office. He is a native of Norfolk, Va.

At a recent meeting of the board of directors, **Fred F. Loock,** formerly vice-president and general manager, was elected president of the **Allen-Bradley Co.,** manufacturers of electric controlling apparatus, Milwaukee, Wis. At the same meeting, **Harry L. Bradley** was named chairman of the board, in which capacity he will continue to be active in the corporate direction of the company. Other officers, who were re-elected, are **R. W. Whitmore,** vice-president and works manager; **Louis Quarles,** secretary; and **A. F. North,** treasurer.

The **Reznor Manufacturing Co.,** Mercer, Pennsylvania, announces the appointment of the **Inland Export Co.** as Reznor's newly-created export division. Located in New Castle, Pennsylvania, Inland will handle Reznor's sales, marketing, promotion, and shipping to all foreign countries except Canada.

Louis L. Schneider has been appointed resident representative at 209 Oakley Drive East, Syracuse, N. Y., for **The Emerson Electric Mfg. Co.**

Raymond V. Pfautsch has been named chief engineer of the **Ilg Electric Ventilating Co.**, Chicago. He succeeds A. G. Sutcliffe who retired on July 1, 1947 after serving a total of thirty-seven years with Ilg, and as chief engineer for the past twenty years. Mr. Pfautsch graduated from the University of Illinois in 1929 with a B.S. degree in mechanical engineering. He immediately entered Ilg's employ as a member of the Engineering Department, specializing in new product development. In 1940 he became assistant chief engineer, a post he occupied until his present advancement. He is a member of ASME.

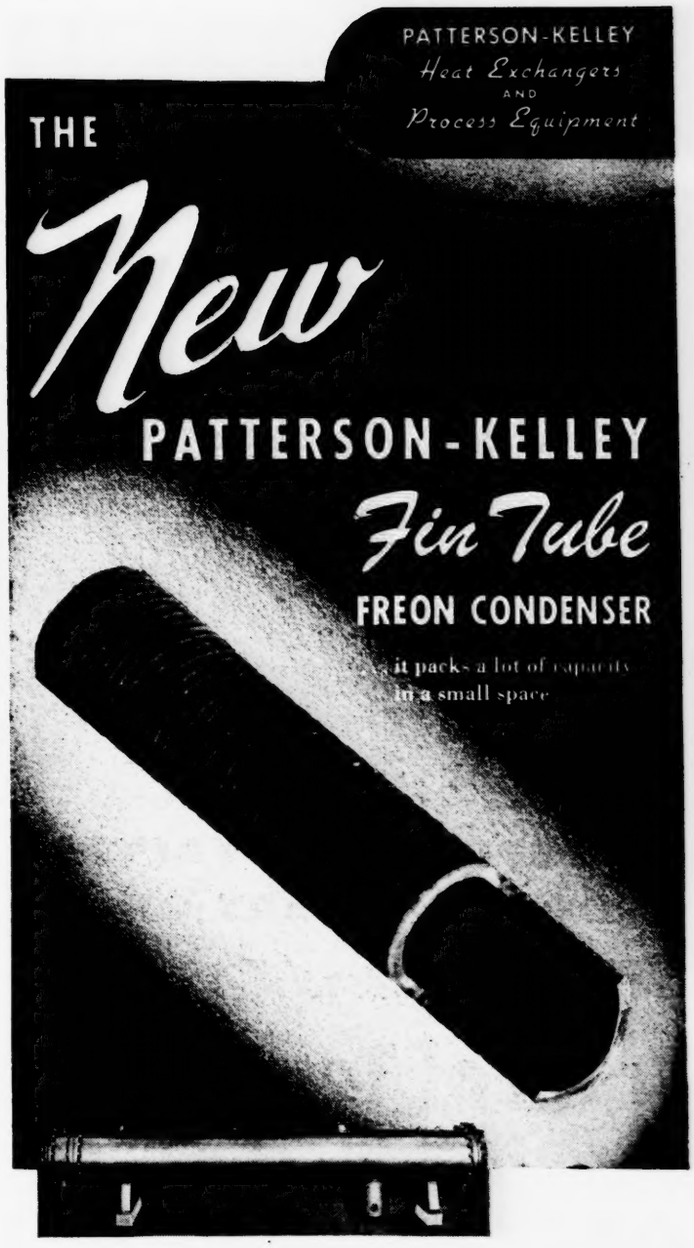
R. V. Pfautsch

Reynolds Metals Co., Louisville, announces the appointment of **Harry E. Weiler** as manager of the Louisville district sales office serving all of Kentucky except Kenton and Campbell counties; in addition, that part of Indiana south of and including Knox, Daviess, Martin, Lawrence, Jackson, Scott, and Jefferson counties.

W. Robert Moore, formerly with the Yarnall-Waring Co. of Philadelphia, is now a partner of **H. Edward Gross Co.**, sales engineers for the **G. C. Breidert Co.**, Los Angeles, manufacturers of the Breidert Air-X-Hauster.

Henry Morrison Reed, 66, chairman of the board of the **American Radiator & Standard Sanitary Corp.**, died in Allegheny General Hospital last month after a long illness. Mr. Reed's entire business career was devoted to American-Standard and its predecessor companies. He was born in Millvale, a suburb of Pittsburgh, on Sept. 16, 1880, and obtained his higher education at the Western University of Pennsylvania—now the University of Pittsburgh, where his athletic superiority brought him to the attention of the officials of the Standard Manufacturing Co. who asked him to take a part-time job in the company while still going to school, in order that he could play on the company's football team. He was so well liked that he obtained a permanent position in the company after completing his schooling. In 1902, when the company was absorbed by the newly organized Standard Sanitary Manufacturing Co., he was given the responsible job of enamel mixer, entrusted with a number of secret formulae. In 1910, Mr. Reed became manager of the largest manufacturing unit in the company. This was the Louisville, Ky., works. His success in the administration of this unit was so outstanding that by 1913 he was promoted to assistant manager of factories. In 1924 he was elected a vice-president of the company and promoted to manager of factories. In the same year he was also appointed to the company's executive committee. In 1928 Mr. Reed was named first vice-president and chairman of the executive committee. In the following year, the Standard Sanitary Manufacturing Co. was merged with the American Radiator Co., forming the American Radiator and Standard Sanitary Corp., and Mr. Reed was named president of the Standard Sanitary Manufacturing Co. affiliate. At the same time he was made a vice-president and director of the amalgamated corporation. In 1938 he became chairman of the board and president of the American Radiator and Standard Sanitary Corp., maintaining that position until 1946.

H. M. Reed



With the fin type of copper tube, approximately 50% extra capacity is provided for any given shell size and tube arrangement over prime surface tube construction. Thus, the buyer of this latest design Patterson-Kelley Freon Condenser can figure on less building space and lower investment cost for his requirements than if he orders a prime surface tube condenser.

For many years, Patterson-Kelley engineers have been specializing in the design and construction of heat transfer equipment, including all types of Freon and other cooling systems. Perhaps with our engineering experience and manufacturing facilities, we can be of service to you in connection with Condensers, Coolers, Heat Exchangers, and other units for your air conditioning or refrigeration systems.

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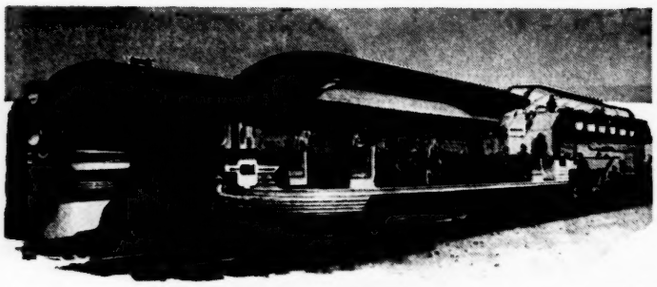
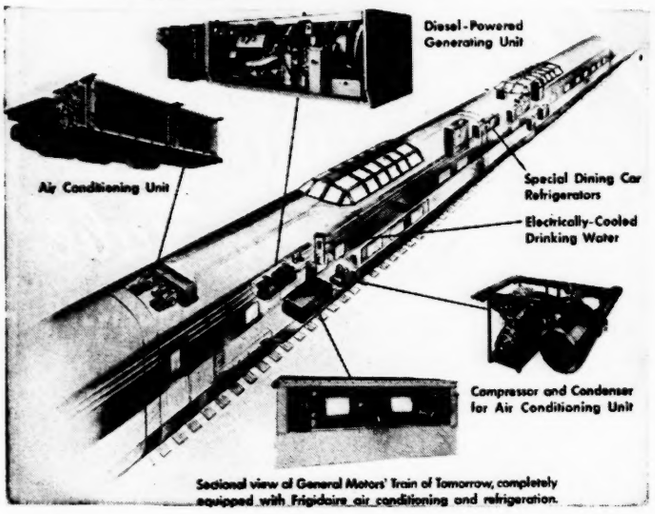
CHICAGO 4—Railway Exch. Bldg. BOSTON 16—96-A Huntington Ave.

Representatives in Principal Cities

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Air Conditioning Unit
Special Dining Car Refrigerators
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Compressor and Condenser for Air Conditioning Unit

Sectional view of General Motors' Train of Tomorrow, completely equipped with Frigidaire air conditioning and refrigeration.

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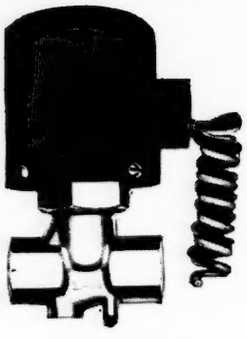
Railroad travelers for years to come will praise the magnificent effort of General Motors Corporation in creating this newest word in traveling comfort and pleasure. For the amazing Train of Tomorrow is smoother-riding, has more restful roomy chairs, the sleeping comfort is increased, you dine in a roof-garden setting and ride in complete air conditioned comfort. All these and more make the Train of Tomorrow a truly remarkable achievement in vacation or business travel . . . a thrill to see today . . . a joy to experience tomorrow.



A-P 73RJ Refrigerant Solenoids—popular with Air Conditioning and Refrigeration Engineers — are doing their part on General Motors Thrilling Train of Tomorrow.

And A-P Dependable Refrigeration Valves are standard equipment on this fine new train. Just as A-P contributed to human comfort in the *first air conditioned streamliners* to race over the rails years ago, so A-P Valves again contribute to comfort in the new Train of Tomorrow.

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Recommended and Installed By Leading Refrigeration Service Engineers

Morris G. Munson has been appointed manager of the Unit Ventilator division of the **Herman Nelson Corp.**, Moline, Ill., manufacturers of heating and ventilating products. Mr. Munson joined Herman Nelson in 1911, only five years after the company had been founded. In 1920, following an absence of four years to attend the University of Illinois, he was sent as a sales engineer to Minneapolis. Eight years later he was appointed field sales manager and, in 1930, sales manager.

M. G. Munson

The Industrial Department of **Dravo Corp.**, Pittsburgh, has opened a Chicago office to handle sales and service of Dravo Counterflo direct fired heaters for commercial and industrial heating and Dravo crane cab coolers for air conditioning crane cabs in steel mills, foundries and chemical plants. **T. W. Eshbach,** who has been active in the heating and ventilating business since 1923, is in charge of the new branch office located at 208 S. La Salle Street.

Henry Valve Co., Chicago, announce the appointment of **Gordon W. Wheeler** as manager in the export department. Mr. Wheeler attended Arkansas University and since the war has been active in the general sales of Henry products. He is also a member of the Export Managers' Club of Chicago.

The assignment of a new group of sales engineers to the branch and regional offices of the **Brown Instrument Co.** has been announced. The new appointees are graduate engineers who have completed post-graduate courses at the Brown School of Instrumentation at Philadelphia. Those appointed and the cities to which each will be assigned: **Edgar Andrews,** Atlanta; **Nilsson S. Bassett,** Boston, **R. J. Bierman** and **Clarence W. Swanson,** Minneapolis; **Edward J. Bryne,** Houston; **Warren H. Erftenbeck,** Buffalo; **David J. Fair,** Dallas; **William R. Hamaker,** Detroit; **Charles F. Hintz,** Chicago; **Lawrence W. King,** New York; **Donald W. Larcen,** Milwaukee; **John F. Smith,** Tulsa, Okla., and **Andrew H. Albee,** Cleveland, Ohio.

Hammel-Dahl Co. of Providence, R. I., manufacturers of automatic control equipment announces the appointment of **O. T. Clarke,** Clarke Sales Engineering Co., Decatur, Ga., as their dealer representative in the southeast territory.

American Air Filter Co., Louisville, Ky. has announced the appointment of **L. O. Ray Clark** as sales representative for both air filtration and dust control equipment for the state of Connecticut. Mr. Clark, a native of Westboro, Mass., is a graduate of Worcester Polytechnic Institute and has served in various capacities with manufacturing companies in Cleveland, Chicago and Hartford. Since 1925, he has been manager of the Hartford office of the B. F. Sturtevant Co.

L. O. Ray Clark

Sarco Company, Inc., manufacturers of steam specialties, announce the removal of their head offices effective Sept. 1st, to the Empire State Building, New York 1, N. Y.

Edward I. Alter has been appointed a sales representative for **General Electric** air conditioning, heating, and refrigeration products in the northwestern district with headquarters in Salt Lake City, Utah.

The Brundage Co., Kalamazoo, Mich., announces that it is expanding its line to include single-width, single-inlet, exhaust blowers for ventilating purposes. These blowers, suitable for connecting directly with duct work, will be distributed through the regular channels. Additional plans now under way include a line of exhaust fans for attic or similar installations which will be available next year.

W. Walter Young has been named comptroller of **Redmond Company, Inc.**, Owosso, Michigan, producers of low-range fractional horsepower electric motors for the heating, ventilating and automotive industries. Mr. Young served as resident manager for five of the seven years he spent with Harry B. Culley and Co., Pittsburgh, accountants and auditors. In New York City he acted in the capacity of CPA for S. D. Leidesdorf and Company, auditing firm. Then he became vice-president and treasurer of RCA Victor Distributing Corporation of Chicago. As comptroller of Redmond Compand, Inc., Mr. Young's activities will cover accounting, financial and credit operations for an organization of 2800 employees who have produced more than 20,000,000 fractional horsepower electric motors in sizes up to 1/15th hp.

W. W. Young

Three new appointments to branch offices were announced by the **Herman Nelson Corp.**, Moline, Ill., manufacturers of heating and ventilating equipment. **Charles W. Trambauer** was appointed manager of the Detroit branch office. **Robert G. Keller**, product application engineer in that office for the past six months, will assist Mr. Trambauer. **Charles R. Anderson** has been appointed product application engineer in the Syracuse branch office. **Charles R. Holsclaw** was assigned to the staff of the Pittsburgh branch office as a product application engineer under Gale M. Heslop, manager.

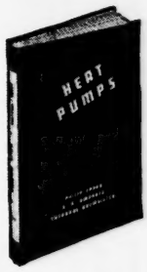
Announcement has been made of the appointment of **Joseph A. Bogan** as business assistant on the staff of **Bituminous Coal Research, Inc.**, Pittsburgh, a position recently authorized by the executive committee of the BCR Board of Directors. Mr. Bogan, who came to the national research agency from Carnegie-Illinois Steel Corp., will handle contractual, patent and similar transactions of a business nature involving BCR, allied industries, manufacturers, and laboratories in which research projects are placed.

Link-Belt Co. announces that **Harold L. Hoefman** has been elected vice-president in charge of manufacturing, located at executive offices, 307 N. Michigan Ave., Chicago. Mr. Hoefman has been general manager of the company's Pershing Road plant, Chicago, since 1943. **David E. Davidson** has been appointed general manager of the Pershing Road plant, to succeed Mr. Hoefman. Mr. Davidson has headed the engineering department at the Pershing Road plant since the beginning of the year.

Thomas A. Clarke has been named regional sales promotion manager for the central region of **Libbey-Owens-Ford Glass Co.** with offices in Toledo. Mr. Clarke comes to Toledo from Dallas where he has been on similar duties for nearly two years.

Is your problem
heating . . . cooling . . . drying?

Read how this important new "tool" can be adapted to your industry



HEAT PUMPS

By PHILIP SPORN, Executive Vice-President and Chief Engineer, American Gas and Electric Service Corporation; E. R. AMBROSE, Air Conditioning Engineer, American Gas and Electric Service Corporation; and THEODORE BAUMEISTER, Consulting Engineer, American Gas and Electric Service Corporation, and Professor of Mechanical Engineering, Columbia University.

Here is a complete, authoritative volume which offers an easily understood technical treatment of the development of the heat-pump, and the progress made in adapting it not only to building heating and cooling service, but also to such industrial processes as: the evaporation and purification of liquids, the drying of solids, and the simultaneous chilling and heating of process fuels. The book contains practical questions and data which those concerned with the development and use of this important new tool want to know now.

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